IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

LG. PHILIPS LCD CO., LTD., **Plaintiff,** **v.** **CHI MEI OPTOELECTRONICS CORPORATION; AU OPTRONICS CORPORATION; AU OPTRONICS CORPORATION AMERICA; TATUNG COMPANY; TATUNG COMPANY OF AMERICA, INC.; AND VIEWSONIC CORPORATION,** **Defendants.**	§	**C.A. No. 06-726-JJF** **JURY TRIAL DEMANDED**
AU OPTRONICS CORPORATION, **Counterclaim Plaintiff,** **v.** **LG. PHILIPS LCD CO., LTD., AND LG. PHILIPS LCD AMERICA, INC.** **Counterclaim Defendants.**	§	**JURY TRIAL DEMANDED**

AUO DEFENDANTS' ANSWER AND COUNTERCLAIM AGAINST PLAINTIFF AND ADDITIONAL PARTY LG. PHILIPS LCD AMERICA, INC.

Defendants AU OPTRONICS CORPORATION and AU OPTRONICS CORPORATION OF AMERICA (collectively "AUO Defendants") hereby answer and assert their affirmative defenses to the First Amended Complaint for Patent Infringement (the

"Amended Complaint") filed by LG. PHILIPS LCD CO., LTD ("LPL"), on or about April 11, 2007 (D.I. 29):

NATURE OF THE ACTION

1. AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of the allegations in paragraph 1 and therefore deny them.

2. AU Optronics Corporation is the owner of United States Patent No. 6,976,781 (the "'781 Patent"), United States Patent No. 6,778,160 (the "'160 Patent"), and United States Patent No. 6,689,629 (the "'629 Patent") (collectively the "AUO Patents").

3. AUO Defendants admit that this purports to be a civil action for patent infringement of United States Patent No. 5,019,002 (the "'002 Patent"), United States Patent No. 5,825,449 (the "'449 Patent"), and United States Patent No. 4,624,737 (the "'737 Patent"). AUO Defendants also admit that LPL alleged willful infringement in this action. AUO further admits that LPL has amended its original complaint in this action, which was filed on or about December 1, 2006, to include claims for declaratory judgment of invalidity and non-infringement of the AUO Patents.

4. AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of the allegations in paragraph 4 and therefore deny them.

THE PARTIES

5. AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of the allegations in paragraph 5 and therefore deny them.

6. AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of the allegations in paragraph 6 and therefore deny them.

7. Defendant AU Optronics Corporation admits that it is a Taiwanese corporation, and it has a place of business at No. 1, Li-Hsin Road 2, Hsinchu Science Park, Hsinchu Taiwan, R.O.C. ("AUO Taiwan"), and that it manufactures LCD products. AUO Defendants further aver that the remaining allegations in paragraph 7 contain characterizations and generalizations in violation of Rule 8's requirement that "[e]ach averment of a pleading shall be simple, concise, and direct," and otherwise deny such allegations.

8. Defendant AU Optronics Corporation America admits that it is a California corporation ("AUO America"). AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of the remaining allegations in paragraph 8 and therefore deny them.

9. AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of the allegations in paragraph 9 and therefore deny them.

10. AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of the allegations in paragraph 10 and therefore deny them.

11. AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of the allegations in paragraph 11 and therefore deny them.

JURISDICTION AND VENUE

12. AUO Defendants admit that the Amended Complaint purports to set forth a claim arising under the patent laws of the United States (Title 35 of the United States Code). AUO Defendants are without sufficient knowledge or information to form a belief as to the remaining allegations in paragraph 12 and therefore deny them.

13. AUO Defendants admit that the Amended Complaint purports to set forth a declaratory judgment claim under 28 U.S.C. §§ 2201 and 2202, and under the patent laws of the

United States (Title 35 of the United States Code). AUO Defendants are without sufficient knowledge or information to form a belief as to the remaining allegations in paragraph 13 and therefore deny them.

14. AUO Defendants understand that paragraph 14 references to LPL's patent infringement claims, and on that basis, subject matter jurisdiction is proper over LPL's patent infringement claims against AUO Defendants under 28 U.S.C. §§ 1331 and 1338(a).

15. AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of the allegations in paragraph 15 and therefore deny them.

16. AUO Taiwan denies that the Court has personal jurisdiction over it. AUO Taiwan also denies that venue is proper. As to any remaining allegations in paragraph 16, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

17 AUO America denies that the Court has personal jurisdiction over it. AUO America also denies that venue is proper. As to any remaining allegations in paragraph 17, the AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

18. AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of the allegations in paragraph 18 and therefore deny them.

THE PATENTS-IN-SUIT

19. AUO Defendants admit that the '002 Patent appears to be entitled "Method of Manufacturing Flat Panel Backplanes including Electrostatic Discharge Prevention and Displays Made Thereby." AUO Defendants deny that the '002 Patent was duly and legally issued. AUO

defendants are without sufficient knowledge and information to form a belief as to the truth of the remaining allegations contained in paragraph 19, and therefore deny them.

20. AUO Defendants admit that the '449 Patent appears to be entitled "Liquid Crystal Display Device and Method of Manufacturing the Same." AUO Defendants deny that the '449 Patent was duly and legally issued. AUO Defendants are without sufficient knowledge and information to form a belief as to the truth of the remaining allegations contained in paragraph 20, and therefore deny them.

21. AUO Defendants admit that the '737 Patent appears to be entitled "Process for Producing Thin-Film Transistor." AUO Defendants deny that the '737 Patent was duly and legally issued. AUO Defendants are without sufficient knowledge and information to form a belief as to the truth of the remaining allegations contained in paragraph 21, and therefore deny them.

22. AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of the allegations in paragraph 22 and therefore deny them.

23. AUO Defendants deny the allegations in paragraph 23 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 23 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

FACTUAL BACKGROUND

24. AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of the allegations in paragraph 24 and therefore deny them.

25. AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of the allegations in paragraph 25 and therefore deny them.

26. AUO Defendants deny the allegations in paragraph 26 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 26 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

27. AUO Defendants deny the allegations in paragraph 27 that are directed to AUO Defendants. As to the remaining allegations in paragraph 27 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

28. AUO Defendants deny the allegations in paragraph 28 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 28 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

29. AUO Defendants aver that paragraph 29 contains multiple oversimplifications, characterizations and generalizations in violation of Rule 8's requirement that "[e]ach averment of a pleading shall be simple, concise, and direct," and otherwise deny the allegations in paragraph 29.

30. AUO Defendants aver that paragraph 30 contains characterizations and generalizations in violation of Rule 8's requirement that "[e]ach averment of a pleading shall be simple, concise, and direct," and otherwise deny the allegations in paragraph 30.

31. AUO Defendants aver that paragraph 31 contains characterizations and generalizations in violation of Rule 8's requirement that "[e]ach averment of a pleading shall be simple, concise, and direct," and otherwise deny the allegations in paragraph 31.

32. AUO Defendants aver that paragraph 32 contains characterizations and generalizations in violation of Rule 8's requirement that "[e]ach averment of a pleading shall be simple, concise, and direct," and otherwise deny the allegations in paragraph 32.

COUNT I

33. AUO Defendants refer to and incorporate herein their responses to paragraphs 1-32 above.

34. AUO Defendants deny the allegations in paragraph 34 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 34 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

35 AUO Defendants deny the allegations in paragraph 35 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 35 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

36. AUO Defendants deny the allegations in paragraph 36 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 36 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

37. AUO Defendants deny the allegations in paragraph 37 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 37 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

COUNT II

38. AUO Defendants refer to and incorporate herein their responses to paragraphs 1-37 above.

39. AUO Defendants deny the allegations in paragraph 39 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 39 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

40. AUO Defendants deny the allegations in paragraph 40 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 40 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

41. AUO Defendants deny the allegations in paragraph 41 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 41 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

42. AUO Defendants deny the allegations in paragraph 42 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 42 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

COUNT III

43. AUO Defendants refer to and incorporate herein their responses to paragraphs 1-42 above.

44. AUO Defendants deny the allegations in paragraph 44 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 44 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

45 AUO Defendants deny the allegations in paragraph 45 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 45 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

46. AUO Defendants deny the allegations in paragraph 46 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 46 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

47. AUO Defendants deny the allegations in paragraph 47 that are directed to the AUO Defendants. As to the remaining allegations in paragraph 47 that are directed to the co-defendants in this action, AUO Defendants are without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

COUNT IV

48. AUO Defendants refer to and incorporate herein their responses to paragraphs 1-47 above.

49. AUO Taiwan admits that it has filed a complaint for patent infringement in the U.S. District Court for the Western District Court of Wisconsin. The complaint alleges LPL infringes the following U.S. patents owned by AUO Taiwan: the '781 Patent, the '160 Patent, and the '629 Patent. As to any remaining allegations in paragraph 49, AUO Defendants are

without sufficient knowledge or information to form a belief as to the truth of such allegations and therefore deny them.

50. The '781 Patent, entitled "Frame and Bezel Structure for Backlight Unit," was duly and legally issued on December 20, 2005. AUO Taiwan is the owner of all rights, title, and interest in and to the '781 Patent. AUO Taiwan denies that the '781 Patent is invalid.

51. The '160 Patent, entitled "Liquid-Crystal Display, Liquid-Crystal Control Circuit, Flicker Inhibition Method, And Liquid-Crystal Driving Method," was duly and legally issued on August 17, 2004. AUO Taiwan is the owner of all rights, title, and interest in and to the '160 Patent. AUO Taiwan denies that the '160 Patent is invalid.

52. The '629 Patent, entitled "Array Substrate for Display, Method of Manufacturing Array Substrate for Display and Display Device Using the Array Substrate," was duly and legally issued on February 10, 2004. AUO Taiwan is the owner of all rights, title, and interest in and to the '629 Patent. AUO Taiwan denies that the '629 Patent is invalid.

53. AUO Taiwan admits that it has asserted the AUO patents against LPL. The remaining allegations in paragraph 53 are legal assertions to which no answer or response is required.

COUNT V

54. AUO Defendants refer to and incorporate herein their responses to paragraphs 1-53 above.

55. LPL has infringed and continues to infringe, either literally or under the doctrine of equivalents, one or more of the claims of the '781 Patent, directly, contributorily, and/or by inducement, by making, using, selling and/or offering to sell in the United States, and/or importing into United States liquid crystal display devices in violation of 35 U.S.C. § 271.

56. LPL has infringed and continues to infringe, either literally or under the doctrine of equivalents, one or more of the claims of the '160 Patent, directly, contributorily, and/or by inducement, by making, using, selling and/or offering to sell in the United States, and/or importing into United States liquid crystal display devices in violation of 35 U.S.C. § 271.

57. LPL has infringed and continues to infringe, either literally or under the doctrine of equivalents, one or more of the claims of the '629 Patent, directly, contributorily, and/or by inducement, by making, using, selling and/or offering to sell in the United States, and/or importing into United States liquid crystal display devices in violation of 35 U.S.C. § 271.

58. AUO Taiwan admits that it has asserted the AUO patents against LPL in the U.S. District Court for the Western District of Wisconsin. The remaining allegations in paragraph 58 are legal assertions to which no answer or response is required.

AFFIRMATIVE DEFENSES

Without conceding that any of the following necessarily must be pleaded as an affirmative defense, or that any of the following are not already at issue by virtue of the foregoing denials, and without prejudice to AUO Defendants' right to plead additional defenses as discovery into the facts of the matter warrants, AUO Defendants hereby assert the following affirmative defenses:

First Affirmative Defense

59. As a First and Separate Affirmative Defense to the Amended Complaint, AUO Defendants allege that the Amended Complaint fails to state a claim upon which relief may be granted and fails to set forth facts sufficient to state a claim for relief against the AUO Defendants.

Second Affirmative Defense

60. As a Second and Separate Affirmative Defense to the Amended Complaint, AUO Defendants allege that their products and processes have not infringed, are not now infringing, and are not threatening to infringe upon any valid and enforceable claim of the '002 Patent, the '449 Patent, and/or the '737 Patent, either literally or under the doctrine of equivalents.

Third Affirmative Defense

61. As a Third and Separate Affirmative Defense to the Amended Complaint, AUO Defendants allege that they have neither directly or indirectly contributed to the infringement of, nor induced another to infringe the '002 Patent, the '449 Patent, and/or the '737 Patent.

Fourth Affirmative Defense

62. As a Fourth and Separate Affirmative Defense to the Amended Complaint, AUO Defendants allege that the '002 Patent, the '449 Patent, and/or the '737 Patent are invalid for failure to comply with one, or more, of the requirements of 35 U.S.C. §§ 101, 102, 103, 112, and/or 116.

Fifth Affirmative Defense

63. As a Fifth and Separate Affirmative Defense to the Amended Complaint, AUO Defendants allege that LPL's claims are barred by the equitable doctrine of laches and/or estoppel.

Sixth Affirmative Defense

64. As a Sixth and Separate Affirmative Defense to the Amended Complaint, AUO Defendants allege that LPL is precluded from construing such patents to cover AUO Defendants' conduct and/or products, and is further estopped from asserting infringement under the doctrine

of equivalents, on the basis of the statements made during the prosecution of one or more of the '002 Patent, the '449 Patent, and/or the '737 Patent.

Seventh Affirmative Defense

65. As a Seventh and Separate Affirmative Defense to the Amended Complaint, AUO Defendants allege that the one or more of the '002 Patent, the '449 Patent, and/or the '737 Patent are unenforceable due to inequitable conduct.

Eighth Affirmative Defense

66. As an Eighth and Separate Affirmative Defense to the Amended Complaint, AUO Defendants allege that Plaintiff's damages are barred and/or limited by the provisions of 35 U.S.C. §§ 271, 286 and/or 287.

COUNTERCLAIM AGAINST PLAINTIFF LG. PHILIPS LCD CO., LTD. AND ADDITIONAL PARTY LG. PHILIPS LCD AMERICA, INC.

By these Counterclaims and pursuant to Rules 13, 19 and/or 20 of the Federal Rules of Civil Procedure, Defendant/Counterclaim Plaintiff AU Optronics Corporation ("AUO Taiwan") seeks injunctive and declaratory relief and damages, including treble or multiple damages, for patent infringement of U.S. Patent No. 6,976,781, U.S. Patent No. 6,778,160, and U.S. Patent No. 6,689,629 (collectively "the AUO Patents"), against Plaintiff LG. Philips LCD Co., Ltd. and additional party LG. Philips LCD America, Inc.

THE COUNTERCLAIM PARTIES

1. Counterclaim Plaintiff AUO Taiwan is a corporation organized and existing under the laws of the Republic of China (Taiwan), with its principal place of business located in Taiwan.

2. Plaintiff/Counterclaim Defendant LG. Philips LCD Co., Ltd. ("LPL") alleges that it is a corporation organized and existing under the laws of the Republic of Korea, having its principal place of business at Seoul, Korea.

3. Upon information and belief, LG. Philips LCD America, Inc. ("LPLA") is a corporation organized and existing under the laws of the State of California, having its principal place of business at 150 East Brokaw Rd., San Jose, CA 95112. Upon information and belief, LPLA is a wholly-owned subsidiary of LPL.

4. Upon information and belief, LPL and LPLA have committed and continue to commit acts of patent infringement within this judicial district by working in concert to make, use, sell, offer to sell, and/or import LCD modules, products, and systems containing such LCD modules in this judicial district that are covered by the AUO Patents. Joinder of LPLA as a counterclaim defendant is needed for just adjudication of AUO Taiwan's patent infringement claims against LPL. Complete relief for AUO Taiwan's counterclaims cannot be accorded between AUO Taiwan and LPL in LPLA's absence. Joinder is therefore proper under Rule 19 of the Federal Rules of Civil Procedure. Alternatively, joinder of LPLA as a counterclaim defendant is proper under Rule 20 of the Federal Rules of Civil Procedure because LPL and LPLA are joint and severally liable for AUO Taiwan's patent infringement claims, AUO Taiwan's counterclaims arise out of the same transaction, occurrence, or series of transactions or occurrences involving both LPL and LPLA, and common questions of law and fact will arise in this action.

JURISDICTION AND VENUE

5. This Court has subject matter jurisdiction under 28 U.S.C. §§ 1331 and 1338(a).

6. This Court has supplemental jurisdiction under 28 U.S.C. § 1367(a) because the counterclaims arise out of the same transaction and occurrence alleged in LPL's Amended Complaint so as to form a part of the same case or controversy within the meaning of Article III of the United States Constitution.

7. This court has personal jurisdiction and venue over LPL, because, *inter alia*, LPL has submitted itself to the jurisdiction of this Court.

8. Upon information and belief, LPLA conducts business in Delaware by entering into and fulfilling the agreements to manufacture and/or supply LCD modules, products, and systems containing such LCD modules to companies located in Delaware. This Court has personal jurisdiction over LPLA.

9. Venue is proper over LPLA in this Court under 28 U.S.C. § 1391 and § 1400. Upon information and belief, LPLA is a wholesale seller of LCD modules, products, and systems containing such LCD modules in the United States. Such LCD modules, products, and systems containing such LCD modules are designed and manufactured by LPL. LPLA has committed and continues to commit acts of patent infringement within this judicial district by working in concert with LPL to make, use, sell, offer to sell, and/or import LCD modules, products, and systems containing such LCD modules in this judicial district that are covered by the AUO Patents.

<u>Counterclaim Count One</u>

(Infringement of the U.S. Patent No. 6,976,781)

10. On December 20, 2005, the United States Patent and Trademark Office duly and legally issued U.S. Patent No. 6,976,781, entitled "Frame and Bezel Structure for Backlight

Unit" (the "'781 Patent"). AUO Taiwan is the owner of all rights, title, and interest in and to the '781 Patent. A copy of the '781 Patent is attached as Exhibit A.

11. On information and belief, Counterclaim Defendants LPL and LPLA have directly infringed, contributorily infringed, and/or actively induced infringement of the '781 Patent by making, using, importing, offering for sale, and/or selling in the United States LCD modules, products, and systems containing such LCD modules covered by one or more claims of the '781 Patent.

12. On information and belief, the infringement of the '781 Patent by LPL and LPLA has been and continues to be deliberate and willful, and such infringement will continue unless LPL and LPLA are preliminary and permanently enjoined by this Court.

13. As a consequence of the infringement by LPL and LPLA complained herein, AUO Taiwan has been damaged and will continue to sustain damages by such acts in amount to be determined at trial and will continue to suffer irreparable loss and injury.

Counterclaim Count Two

(Infringement of the U.S. Patent No. 6,778,160)

14. On August 17, 2004, the United States Patent and Trademark Office duly and legally issued U.S. Patent No. 6,778,160, entitled "Liquid-Crystal Display, Liquid-Crystal Control Circuit, Flicker Inhibition Method, And Liquid-Crystal Driving Method" (the '160 Patent). AUO Taiwan is the owner of all rights, title, and interest in and to the '160 Patent. A copy of the '160 Patent is attached as Exhibit B.

15. On information and belief, Counterclaim Defendants LPL and LPLA have directly infringed, contributorily infringed, and/or actively induced infringement of the '160 Patent by making, using, importing, offering for sale, and/or selling in the United States LCD

modules, products, and systems containing such LCD modules covered by one or more claims of the '160 Patent.

16. On information and belief, the infringement of the '160 Patent by LPL and LPLA has been and continues to be deliberate and willful, and such infringement will continue unless LPL and LPLA are preliminary and permanently enjoined by this Court.

17. As a consequence of the infringement of LPL and LPLA complained herein, AUO Taiwan has been damaged and will continue to sustain damages by such acts in amount to be determined at trial and will continue to suffer irreparable loss and injury.

Counterclaim Count Three

(Infringement of the U.S. Patent No. 6,689,629)

18. On February 10, 2004, the United States Patent and Trademark Office duly and legally issued U.S. Patent No. 6,689,629, entitled "Array Substrate for Display, Method of Manufacturing Array Substrate for Display and Display Device Using the Array Substrate" (the "'629 Patent"). AUO Taiwan is the owner of all rights, title, and interest in and to the '629 Patent. A copy of the '629 Patent is attached as Exhibit C.

19. On information and belief, Counterclaim Defendants LPL and LPLA have directly infringed, contributorily infringed, and/or actively induced infringement of the '629 Patent by making, using, importing, offering for sale, and/or selling in the United States LCD modules, products, and systems containing such LCD modules covered by one or more claims of the '629 Patent.

20. On information and belief, the infringement of the '629 Patent by LPL and LPLA has been and continues to be deliberate and willful, and such infringement will continue unless LPL and LPLA are preliminary and permanently enjoined by this Court.

21. As a consequence of the infringement of LPL and LPLA complained herein, AUO Taiwan has been damaged and will continue to sustain damages by such acts in amount to be determined at trial and will continue to suffer irreparable loss and injury.

EXCEPTIONAL CASE

22. This is an exceptional case under 35 U.S.C. § 285 and, as such, AUO Defendants/Counterclaim Plaintiff AUO Taiwan are entitled to recover from Plaintiff LPL/Counterclaim Defendants LPL and LPLA the attorneys' fees and costs incurred in connection with this action.

PRAYER FOR RELIEF

WHEREFORE, AUO Defendants/Counterclaim Plaintiff AUO Taiwan respectfully request that the Court:

A. Order that LPLA be made a counterclaim defendant to respond to AUO Taiwan's Counterclaim.

B. Dismiss Plaintiff LPL's First Amended Complaint with prejudice,

C. Enter judgment in favor of AUO Defendants and declare that each of the claims of the '002 Patent, the '449 Patent, and the '737 Patent are invalid;

D. Enter judgment in favor of AUO Defendants and declare that AUO Defendants have not infringed any claim of the '002 Patent, the '449 Patent, and the '737 Patent either literally or under the doctrine of equivalents.

E. Enter judgment in favor of AUO Defendants and declare that the '781 Patent, the '160 Patent, and the '629 Patent are valid and enforceable.

F. Enter judgment in favor of Counterclaim Plaintiff AUO Taiwan and declare that LPL and LPLA have infringed, actively induced infringement of, and contributorily infringed the '781 Patent, the '160 Patent, and the '629 Patent.

G. Preliminary and permanently enjoin LPL and LPLA from further infringement of the '781 Patent, the '160 Patent, and the '629 Patent by unauthorized use of the inventions patented therein, by LPL and LPLA, and their officers, agents, servants, employees, attorneys and all persons in active concert or participation with them.

H. Award damages and prejudgment interest to Counterclaim Plaintiff AUO Taiwan for the infringement of the '781 Patent, the '160 Patent, and the '629 Patent by LPL and LPLA.

I. Declare that the infringement of the '781 Patent, the '160 Patent, and the '629 Patent by LPL and LPLA is willful, and award treble damages to AUO Taiwan as provided by 35 U.S.C. § 284.

J. Declare that this is an exceptional case under 35 U.S.C. § 285 and award to AUO Defendants/Counterclaim Plaintiff AUO Taiwan their attorneys' fees and costs; and

K. Grant such other and further relief as the Court may deem just and proper.

DEMAND FOR JURY TRIAL

Pursuant to Rule 38(b) of the Federal Rules of Civil Procedure, AU OPTRONICS CORPORATION and AU OPTRONICS CORPORATION AMERICA respectfully demand a trial by jury on all issues so triable in this action.

DATED: June 5, 2007

YOUNG CONAWAY STARGATT & TAYLOR, LLP

/s/ Karen L. Pascale

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CERTIFICATE OF SERVICE

I, Karen L. Pascale, Esquire, hereby certify that on June 5, 2007, I caused to be electronically filed a true and correct copy of the foregoing document with the Clerk of the Court using CM/ECF, which will send notification that such filing is available for viewing and downloading to the following counsel of record:

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I further certify that I caused a copy of the foregoing document to be served by e-mail and hand delivery on the above-listed counsel of record and on the following non-registered participants in the manner indicated:

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EXHIBIT A

US006976781B2

(12) **United States Patent**
Chu et al.

(10) **Patent No.:** **US 6,976,781 B2**
(45) **Date of Patent:** **Dec. 20, 2005**

(54) **FRAME AND BEZEL STRUCTURE FOR BACKLIGHT UNIT**

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(73) Assignee: **AU Optronics Corp.**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 31 days.

(21) Appl. No.: **10/446,103**

(22) Filed: **May 28, 2003**

(65) **Prior Publication Data**

US 2004/0080952 A1 Apr. 29, 2004

(30) **Foreign Application Priority Data**

Oct. 25, 2002 (TW) .... 91125324 A

(51) **Int. Cl.**7 .... **F21V 7/04**
(52) **U.S. Cl.** **362/633**; 349/58; 40/209; 40/781
(58) **Field of Search** 362/23, 26, 28, 362/31, 551, 559, 560, 561, 362, 367, 368, 362/374, 382, 396, 433, 444, 600, 632, 633, 362/634; 349/58, 60, 56; 385/129; 40/204, 40/209, 124.02, 661.02, 541, 549, 700, 714, 40/781

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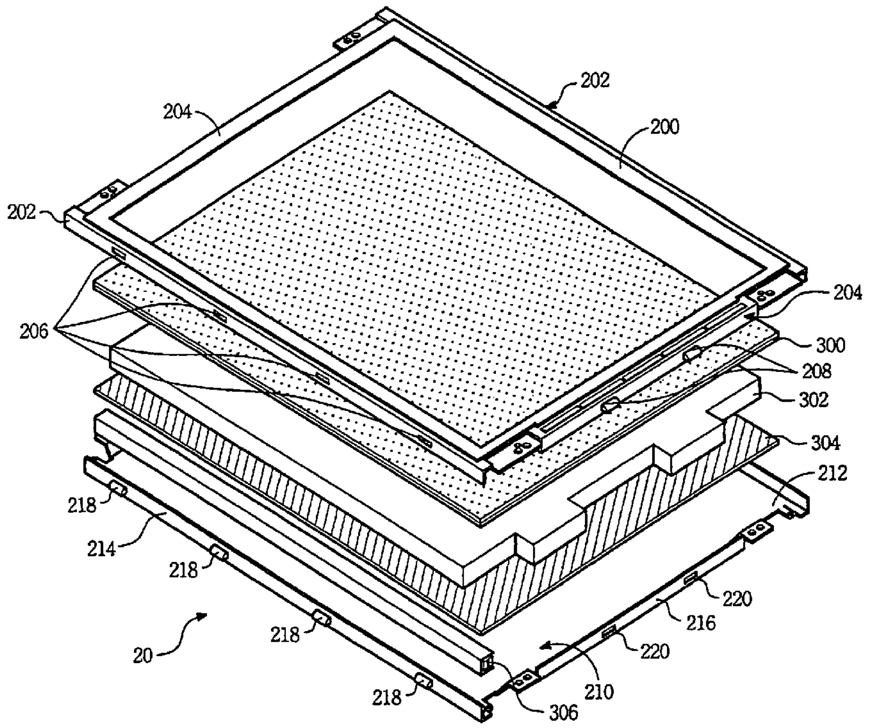
Assistant Examiner—Ismael Negron
(74) *Attorney, Agent, or Firm*—Troxell Law Office, PLLC

(57) **ABSTRACT**

A frame including a first edge and a second edge, wherein on outer surfaces of the first edge, first hooks are formed to protrude outwardly, and on outer surfaces of the second edge, first holes are formed. A bezel has a first sidewall and a second sidewall, wherein on the first sidewall, second holes are formed, and on outer surfaces of the second sidewall, second hooks are formed to protrude outwardly. When the frame is mounted onto the bezel, the first edge is disposed onto inside surfaces of the first sidewall, and the first hooks are inserted and engaged in the second holes for fastening the frame and bezel, simultaneously the second edge is disposed onto the outside surfaces of the second sidewall, and the second hooks are inserted and engaged in the first holes for fastening the frame and the bezel.

13 Claims, 5 Drawing Sheets



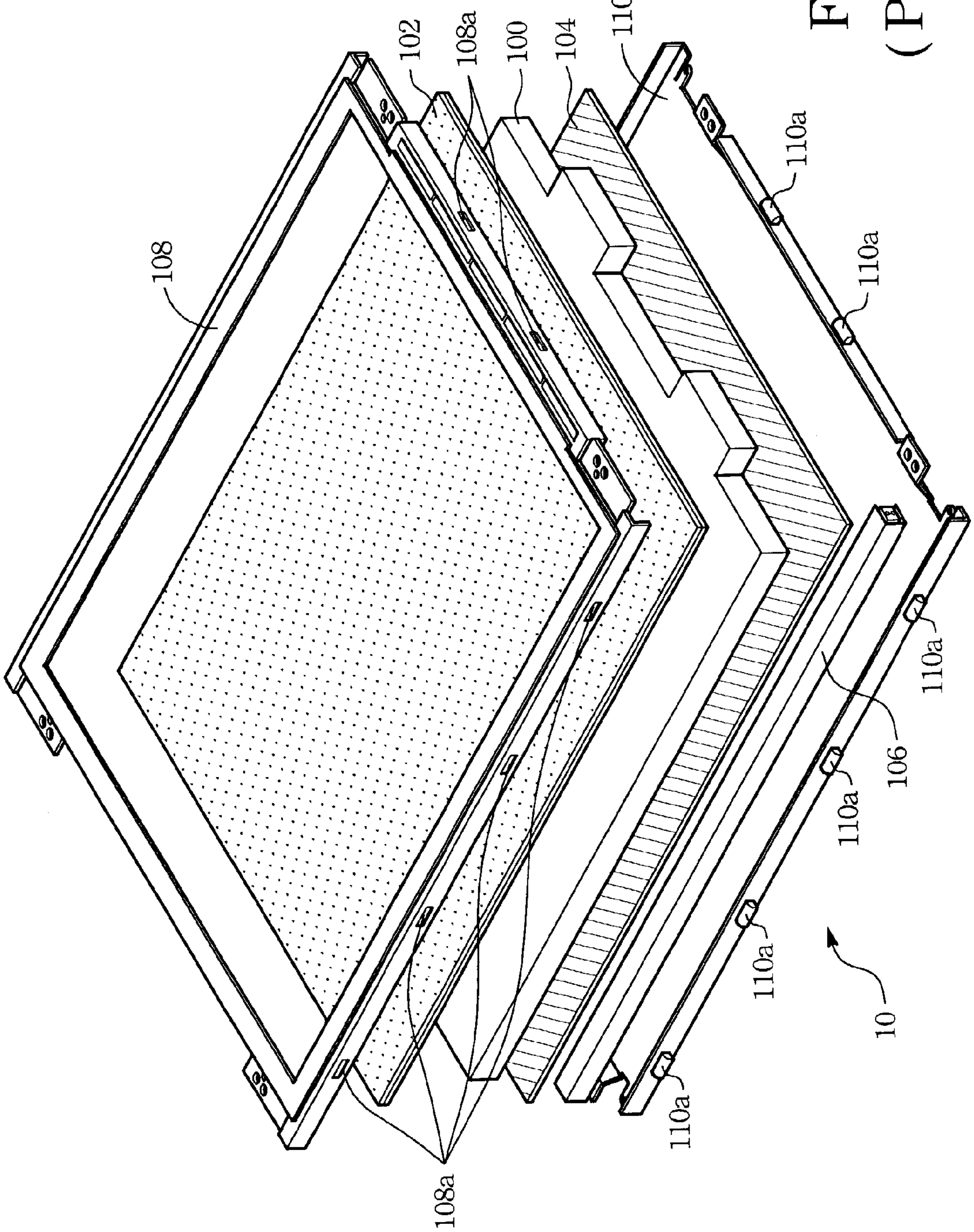


Figure 1
(Prior Art)

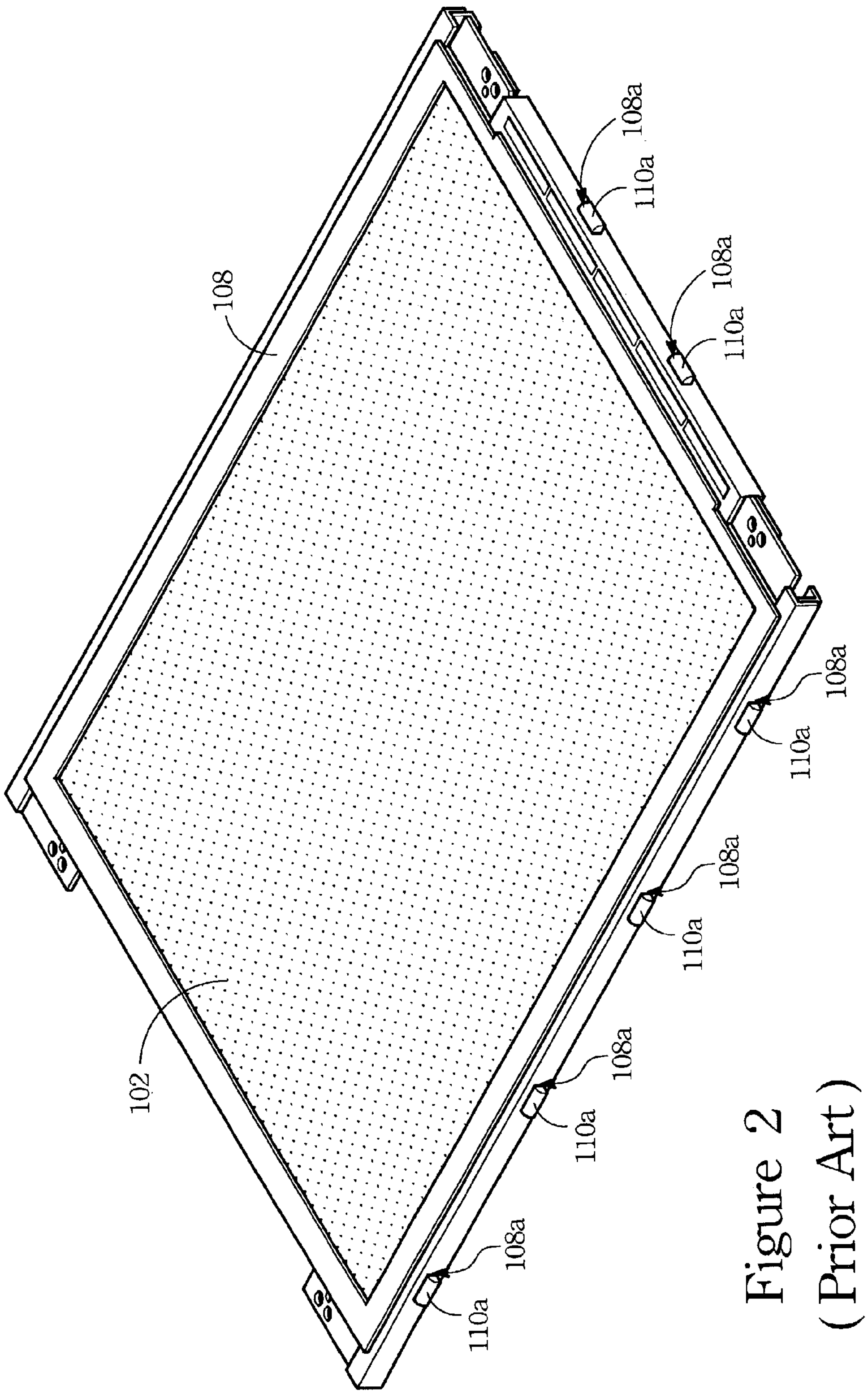


Figure 2
(Prior Art)

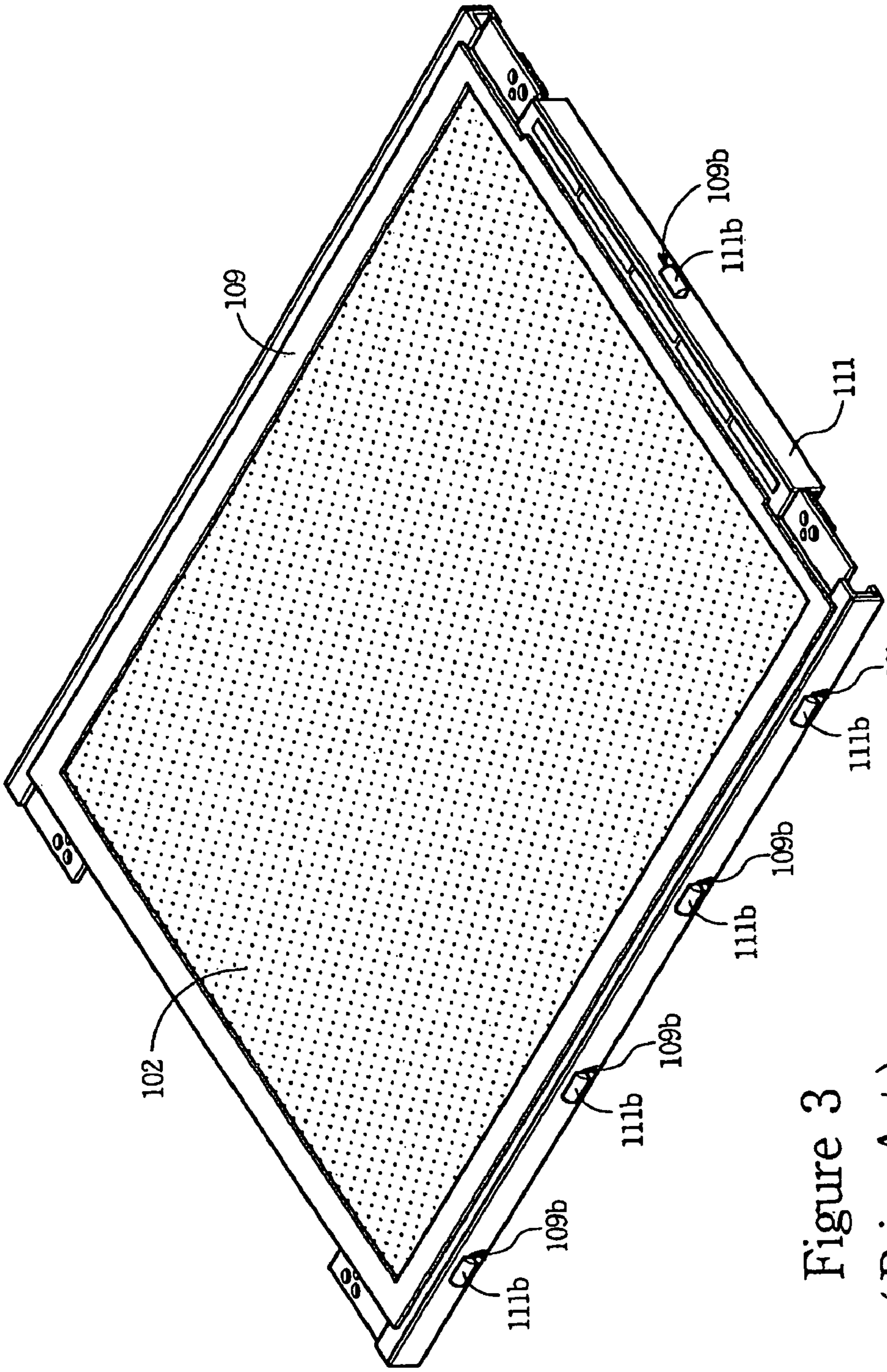


Figure 3
(Prior Art)

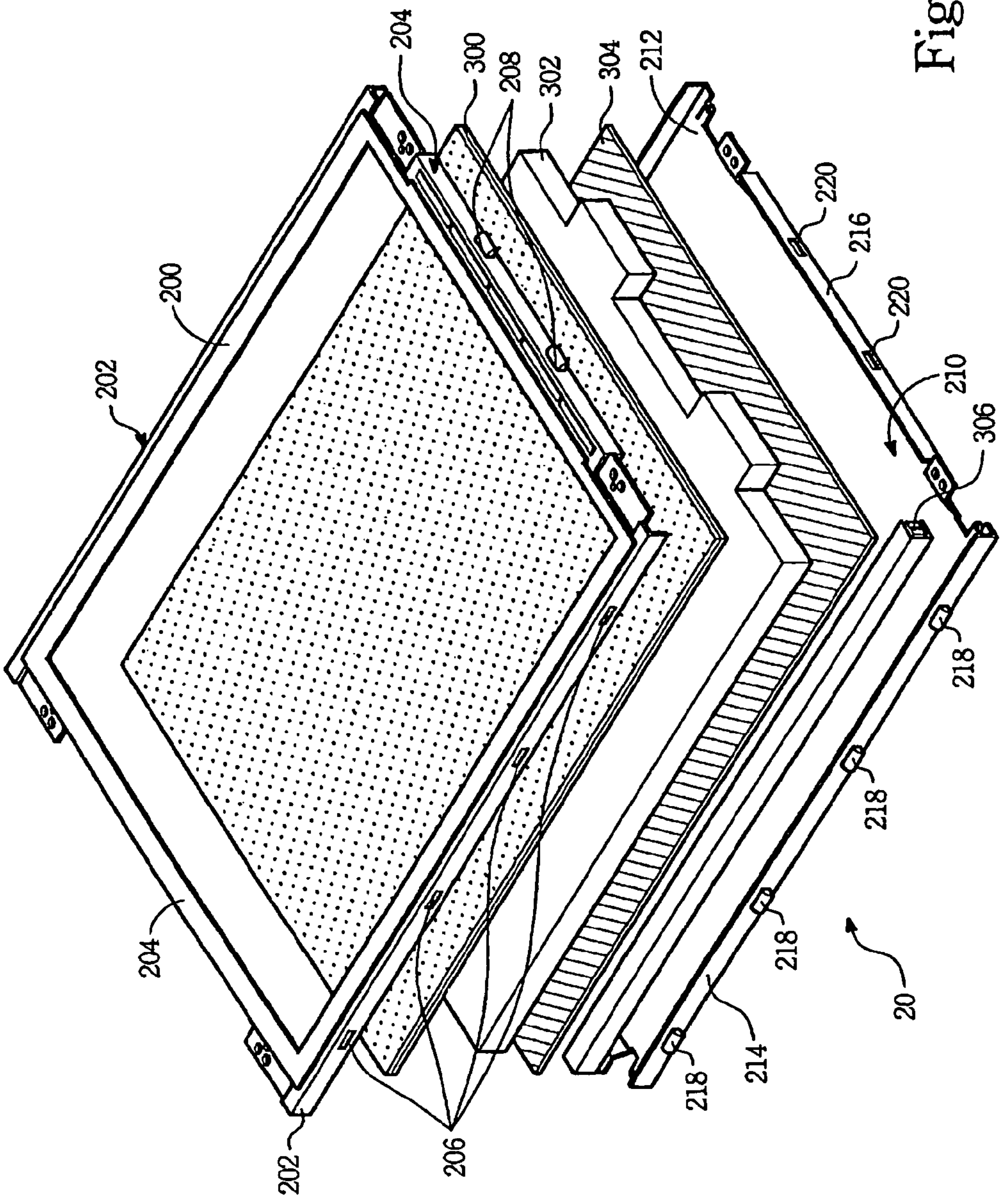

200
202
204
300
208
302
304
212
220
216
220
210
306
218
218
218
218
214
20
206
204
202

Figure 4

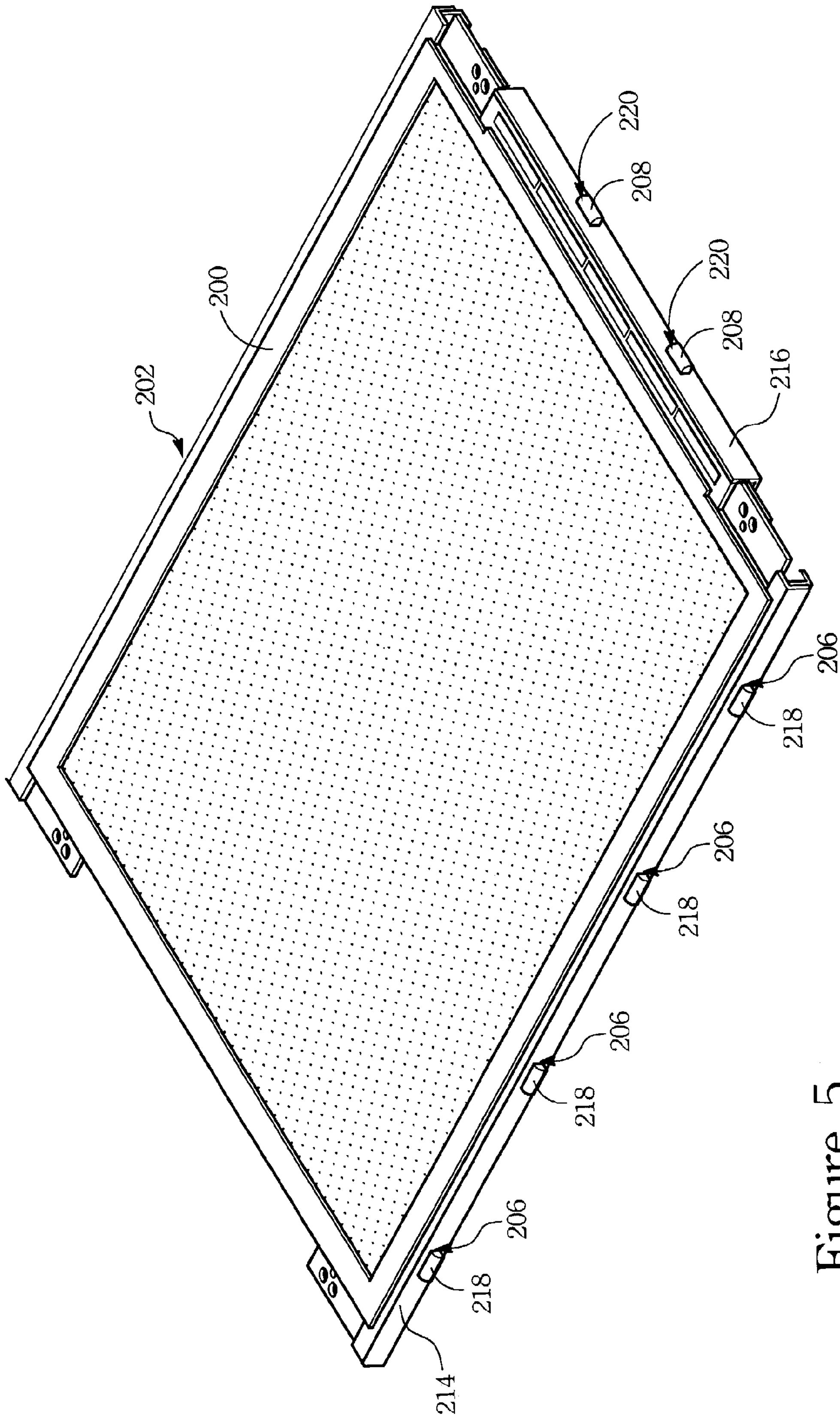


Figure 5

FRAME AND BEZEL STRUCTURE FOR BACKLIGHT UNIT

FIELD OF THE INVENTION

The present invention relates to a backlight unit of a liquid crystal display, and more specifically, to a new assembling manner for mounting a frame onto a bezel to provide the assembling structure the reinforced supporting strength and to provide the convenience of disassembling the frame from the bezel.

BACKGROUND OF THE INVENTION

With the advance of techniques for manufacturing thin-film transistors, the liquid crystal displays (LCD) are widely applied in electrical products, such as PDAs, laptops, digital cameras, cell phones, high resolution television sets, etc. due to advantages as portability, non-radiation and saving electricity. Especially when the manufactures devote themselves to further research and improve the materials, processes and equipments for producing LCD devices, the qualities of the LCDs are promoted and prime costs are reduced substantially. It is required to introduce backlight units into the LCDs for illumination because the liquid crystal molecules are non-illumination materials. Therefore the backlight unit is the most importance element for manufacturing the LCD devices, and the performance thereof is closely related to the displaying effect of the LCD.

Refer to FIG. **1**, the typical backlight unit **10** applied to the LCDs comprises a lightguide plate **100**, optical films **102**, a reflector sheet **104**, a tubular lamp **106**, a frame **108** and a backbezel **110**. The frame **108** and the bezel **110** are assembled together to contain and fabricate above components. When the backlight unit **10** is assembled, the reflector sheet **104** is disposed on the bezel **110**, and then the lightguide plate **100** and the optical films **102** are disposed in sequence on the reflector sheet **104**. Next, the frame **108** is mounted and fastened onto the bezel **110**. And the tubular lamp **106** is inserted into the backlight unit **10** through an opening at the corner of the frame **108**. The tubular lamp **106** is inserted into the slot between the lightguide plate **100** and one edge of bezel **110**.

It is noted that for the purpose of fastening the frame **108** onto the bezel **110** as shown in FIG. **1**, some hooks **110***a* are formed to protrude outwardly from the outside of the sidewalls of the bezel **110**, and correspondingly on the sidewalls of the frame **108** some holes **108***a* are formed. Thus, when the frame **108** is mounted on the bezel **110**, the hooks **110***a* of the bezel **110** are inserted and engaged in the holes **108***a* of the frame **108** for fastening the frame **108** and the bezel **110**. Please refer to FIG. **2**, the assembling structure of the frame **108** and the bezel **110** is illustrated.

Except the aforementioned assembling manner, in some backlight unit, as shown in FIG. **3**, on the sidewalls of the bezel **111** are formed some holes **111***b*, and correspondingly on edges of the frame **109** some hooks **109***b* are fabricated. Therefore, when the frame **109** is disposed onto the bezel **111**, the outside surfaces of the edges of the frame **109** are enclosed and attached by the inside surfaces of the sidewalls of the bezel **111**, and the hooks **109***b* of the frame **109** are inserted and engaged in the respective holes **111***b* of the bezel **111** for fastening the frame **108** and the bezel **111**.

In general, when the assembling manner shown in FIG. **2** is introduced, the edges of the frame **108** are mounted on the outside of the sidewalls of the bezel **110**. It is noted that because the frame **108** made of resin material is flexible and

elastic, the operator can disassemble the frame **108** from the bezel **110** easily just by pressing back slightly the hooks **110***a* of the bezel **110** and simultaneously pulling the edges of the frame **108**. Even though such assembling manner has the advantage of easy disassembling, however, the structure strength of the backlight unit is worse due to the resin frame **108** is pliable.

Besides, when the assembling manner shown in FIG. **3** is used, the edges of the frame **109** are enclosed and attached by the inside surfaces of the sidewalls of the bezel **111**. Because the edge of the frame **109** is wedged between the bezel **111** and the lightguide plate **100**, the structure strength of such backlight unit is reinforced. However, due to the bezel **111** made of metal material is too hard, it is difficult to disassemble the frame **109** from the bezel **111**. The operators have to exert themselves to reject the hooks back and extract the frame **109** from the bezel **111**. Apparently, such assembling design will increase the degree of difficulty in reassembling procedures. Under these conditions, the manufacturers usually have to trade off between structure strength and disassembling convenience. And apparently there is a requirement to figure out a new mounting manner for obtaining above two advantages both.

SUMMARY OF THE INVENTION

The prime objective of the present invention is to provide a new assembling manner of the backlight unit for obtaining the both advantages of disassembling convenience and increasing structure strength.

The present invention discloses an assembling structure of a backlight module. The assembling structure comprises following components. A rectangular frame has a long edge and a short edge, wherein first hooks are formed and protruding outwardly on outside surfaces of said long edge, and first holes are formed on said short edge. A rectangular bezel has a long sidewall and a short sidewall, wherein second holes are formed on said long sidewall and second hooks are formed and protruding outwardly on outside surfaces of said short sidewall. When said rectangular frame is mounted onto said rectangular bezel, said long edge is attached to inside surfaces of said long sidewall and said first hooks are inserted and engaged in said second holes for fastening said rectangular frame and said rectangular bezel, and simultaneously said short edge is attached to said outside surfaces of said short sidewall and said second hooks are inserted and engaged in said first holes for fastening said rectangular frame and said rectangular bezel.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIG. **1** illustrates the assembling manner of the components of the backlight unit;

FIGS. **2** & **3** illustrates the conventional assembling manner of the backlight unit;

FIG. **4** illustrates the frame and the bezel fabricated according to the present invention; and

FIG. **5** illustrates the mounting manner of the frame and the bezel according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As aforementioned, the assembling structure **20** is introduced to contain and fabricate various components of the backlight unit, such as a lightguide plate **302**, optical films **300**, a reflector sheet **304**, a tubular lamp **306** and etc. The assembling structure **20** comprises a frame **200** and a bezel **210**. The frame **200** has a rectangular shape composed of two long edges **202** and two short edges **204**. On each long edge **202** a plurality of holes **206** are formed. And on outer surfaces of each short edge **204** a plurality of hooks **208** are fabricated.

Correspondingly, the bezel **210** also has a rectangular shape. As shown in the FIGURE, the bezel **210** has a rectangular board **212**, two long sidewalls **214** and two short sidewalls **216** which are erect from the edges of the rectangular board **212** respectively. On outer surfaces of each long sidewall **214** a plurality of hooks **218** are formed and protruding outwardly. And on each short sidewall **216** a plurality of holes **220** are formed.

As aforementioned, when the components of the backlight unit are assembled, the reflector sheet **304**, the lightguide plate **302** and optical films **300** are disposed in sequence onto the rectangular board **212** of the bezel **210**. As shown in FIG. **4**, the reflector sheet **304** is disposed on the rectangular board **212** of the bezel **210**, the lightguide plate **302** is disposed on the reflector sheet **304**, and the optical films **300** are disposed on the lightguide plate **302**. Then, the frame **200** is mounted onto the bezel **210** to contain those components. The long edges **202** of the frame **200** are disposed and attached onto the outside surfaces of the long sidewalls **214** of the bezel **210**. Namely, the long sidewall **214** is covered by the edge **202**. And the hooks **218** on the outer surfaces of the long sidewall **214** are inserted and engaged in the holes **206** of the long edge **202** to fasten the frame **200** onto the bezel **210**. In the mean time, the short edge **204** is disposed and attached onto the inside surfaces of the short sidewall **216** of the bezel **210**, and the hooks **208** on the outside surfaces of the short edge **204** are inserted and engaged in the holes **220** of the short sidewall **216** to fasten the frame **200** and the bezel **210**, as shown in FIG. **5**.

It is noted that in most applications of the backlight module the frame **200** is made of flexible materials such as resin, and the bezel **210** is made of metal materials such as aluminum. Therefore, the short sidewalls **216** of the bezel **210** covering the outside of the short edge **200** of the short sidewall **216** can reinforce the structure strength of the backlight unit. AT the same time, because the long edges **202** of the frame **200** are attached to the outside of the long sidewalls **214** of the bezel **210**, the frame **200** can be disassembled from the bezel **210** very easily by pressing slightly the hooks **218** of the bezel **210** and pulling the long edges **202** of the frame **200**.

it is noted that in the above embodiment, the long edges **202** of the frame **200** are formed with the holes **206**, and the short edges **204** are formed with hooks **218**. However, in another embodiment, other mounting manners can be chosen according to the requirements of designing backlight units. For example, the short edges of the frame can be defined with holes, and the long edges of the frame can be fabricated with protruding hooks. Correspondingly, the short sidewalls of the bezel are fabricated with hooks and the long sidewalls thereof are drilled to have holes thereon. Thus, the assembling structure with the frame mounted onto the bezel can have both the advantages of enhancing structure strength and easy disassembling.

Besides, in a further embodiment, only one edge of the rectangular frame is fabricated with holes and the others (the three edges) are fabricated with protruding hooks. Certainly, in this design, only one sidewall of the bezel is fabricated with hooks, and the others are fabricated with holes for fastening the frame and the bezel.

It is noted that in most backlight units the tubular lamp of the backlight unit is disposed on the inside of one long sidewall of the bezel. So in a preferred embodiment the long edges of the frame are disposed to attach the outside surfaces of the long sidewalls of the bezel. Therefore, the long sidewall of the bezel is more closely to the tubular lamp and can have efficient heat dissipations due to the metal material of the bezel. And that can prevent the overheat issues of the tubular lamp in the prior art. In other words, the long sidewall adjacent to the tubular lamp is fabricated with hooks that are protruding outwardly from the outside surfaces of the long sidewall. And on the corresponding long edges of the frame the holes are formed for receiving and wedging the hooks of the bezel, in order to fasten the frame and the bezel and to let the sidewall of the metal bezel more closely to the tubular lamp.

Except the design of assembling the frame and the bezel as illustrated in the above embodiment, the fastening manner can also be applied to the assembling structure of two frames. For example, some first hooks are fabricated on the outside of the first edge of an upper frame, and on the second edges of the upper frame some first holes are formed. In the mean time, on the third edges of a lower frame some second holes are formed to receive and wedge the first hooks, and outside the fourth edges of the lower frame some second hooks are fabricated to insert and engage the first holes for fastening the upper and lower frames.

The assembling structures provided in the present invention have many advantages. Because the two long edges of the frame are disposed to mount and cover the two long sidewalls of the bezel, and the two short edges of the frame are disposed inside the two short sidewalls of the bezel. So the assembling structures can obtain both the reinforced structure strengths and the disassembling convenience.

As is understood by a person skilled in the art, the foregoing preferred embodiment of the present invention is illustrated of the present invention rather than limiting of the present invention. It is intended to cover various modifications and similar arrangements included within the spirit and scope of the appended claims, the scope of which should be accorded the broadest interpretation so as to encompass all such modifications and similar design.

What is claimed is:

1. An assembling structure of a backlight module for containing and fabricating components of said backlight module, said assembling structure comprising:

a frame, having a first edge and a second edge, wherein on outer surfaces of said first edge a plurality of first hooks are formed to protrude outwardly, and on outer surfaces of said second edge a plurality of first holes are formed;

a bezel, made of metal material, having a first sidewall and a second sidewall, wherein on said first sidewall a plurality of second holes are formed, and on outer surfaces of said second sidewall a plurality of second hooks are formed to protrude outwardly;

wherein said first edge is disposed onto inside surfaces of said first sidewall, said first hooks are inserted and engaged in said second holes, said second edge is disposed onto outside surfaces of said second sidewall, and said second hooks are inserted and engaged in said first holes as said frame is mounted onto said bezel.

2. The assembling structure of claim **1**, wherein said frame is made of resin material.

3. The assembling structure of claim **1**, wherein a tubular lamp of said backlight module is disposed inside and adjacent to said second sidewall of said bezel.

4. The assembling structure of claim **1**, wherein said frame has a rectangular shape, and said first edge of said frame is a short edge, and said second edge of said frame is a long edge.

5. The assembling structure of claim **1**, wherein said bezel has a rectangular board, and said first sidewall and said second sidewall are erect from edges of said rectangular board, said first sidewall is a short sidewall of said bezel and said second sidewall is a long sidewall thereof.

6. An assembling structure of a backlight module for containing and assembling components of said backlight module, said assembling structure comprising:

an upper frame, made of resin material, having a first edge and a second edge, wherein on outside surfaces of said first edge first hooks are formed to protrude outwardly, and on said second edge first holes are formed; and

a lower frame, made of metal material, having a third edge and a fourth edge, wherein on said third edge second holes are formed, and on outside surfaces of said forth edge second hooks are formed to protrude outwardly;

wherein said first edge is disposed inside said third edge and said first hooks are inserted and engaged in said second holes, said second edge is attached to the outside surfaces of said fourth edge, and said second hooks are inserted and engaged in said first holes as the upper frame is mounted onto the lower frame.

7. The assembling structure of claim **6**, wherein a tubular lamp of said backlight module is disposed inside said fourth edge of said lower frame.

8. A backlight unit comprising:

a bezel made of metal material, having a first sidewall and a second sidewall, wherein on said first sidewall a plurality of first holes are formed, and on outer surfaces

of said second sidewall a plurality of first hooks are formed to protrude outwardly;

a lightguide plate, disposed above said bezel;

a frame, disposed above said lightguide plate and mounted onto said bezel, having a first edge and a second edge, wherein on outer surfaces of said first edge a plurality of second hooks are formed to protrude outwardly, and on outer surfaces of said second edge a plurality of second holes are formed, wherein said first edge is disposed onto inside surfaces of said first sidewall, and said second hooks are inserted and engaged in said first holes for fastening said frame and said bezel, simultaneously said second edge is disposed onto outside surfaces of said second sidewall, and said first hooks are inserted and engaged in said second holes for fastening said frame and said bezel; and

a tubular lamp, disposed on said bezel, beside said lightguide plate, and adjacent to inside surfaces of said second sidewall of said bezel.

9. The backlight unit of claim **8**, wherein said frame is made of resin material.

10. The backlight unit of claim **8**, further comprising a reflector sheet, disposed on said bezel and beneath said lightguide plate.

11. The backlight unit of claim **8**, further comprising optical films, disposed on said lightguide plate and under said frame.

12. The backlight unit of claim **8**, wherein said frame has a rectangular shape, and said first edge of said frame is a short edge, and said second edge of said frame is a long edge.

13. The backlight unit of claim **12**, wherein said bezel has a rectangular board, and said first sidewall and said second sidewall are erect from edges of said rectangular board, said first sidewall is a short sidewall of said bezel and said second sidewall is a long sidewall thereof.

* * * * *

EXHIBIT B

US006778160B2

(12) **United States Patent**
Kubota et al.

(10) **Patent No.: US 6,778,160 B2**
(45) **Date of Patent: Aug. 17, 2004**

(54) **LIQUID-CRYSTAL DISPLAY, LIQUID-CRYSTAL CONTROL CIRCUIT, FLICKER INHIBITION METHOD, AND LIQUID-CRYSTAL DRIVING METHOD**

(75) Inventors: **Tetsu Kubota**, Fujisawa (JP); **Akihiro Funakoshi**, Kamakura (JP); **Takuya Ishikawa**, Hino (JP)

(73) Assignee: **International Business Machines Corporation**, Armonk, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 218 days.

(21) Appl. No.: **09/760,131**

(22) Filed: **Jan. 12, 2001**

(65) **Prior Publication Data**

US 2001/0024181 A1 Sep. 27, 2001

(30) **Foreign Application Priority Data**

Jan. 17, 2000 (JP) 2000-007816

(51) **Int. Cl.**[7] **G09G 3/36**

(52) **U.S. Cl.** **345/89**; 345/98; 345/77; 345/88; 345/690

(58) **Field of Search** 345/88, 63, 89, 345/77, 90, 87, 611, 690, 147, 148, 211, 102, 212

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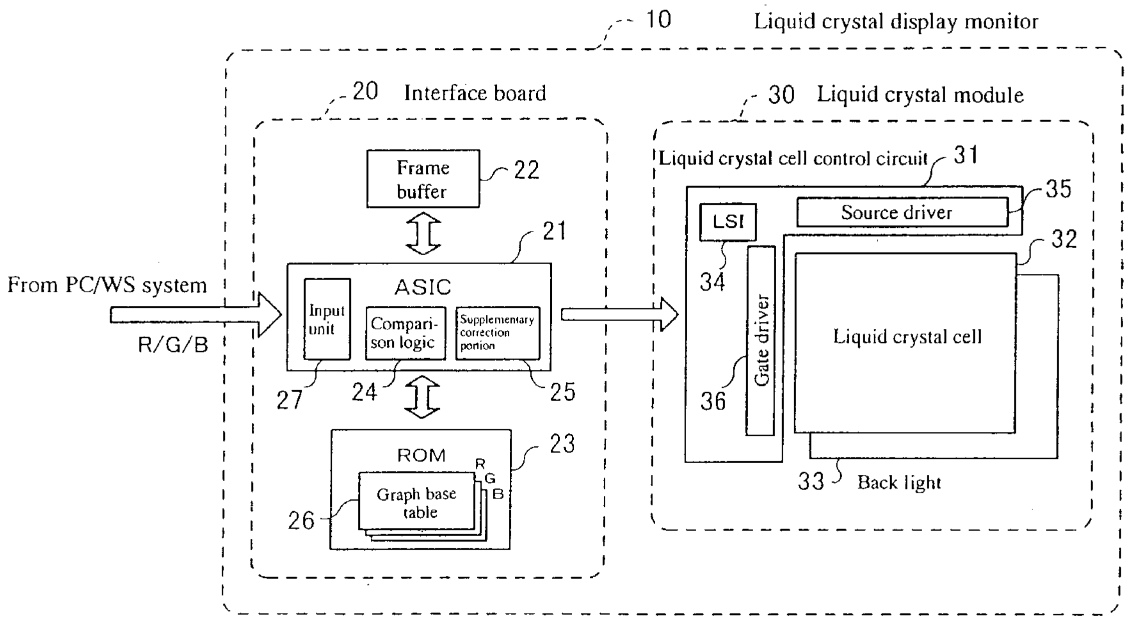
Primary Examiner—Regina Liang
Assistant Examiner—Jennifer T. Nguyen
(74) *Attorney, Agent, or Firm*—Derek S. Jennings; David Aker

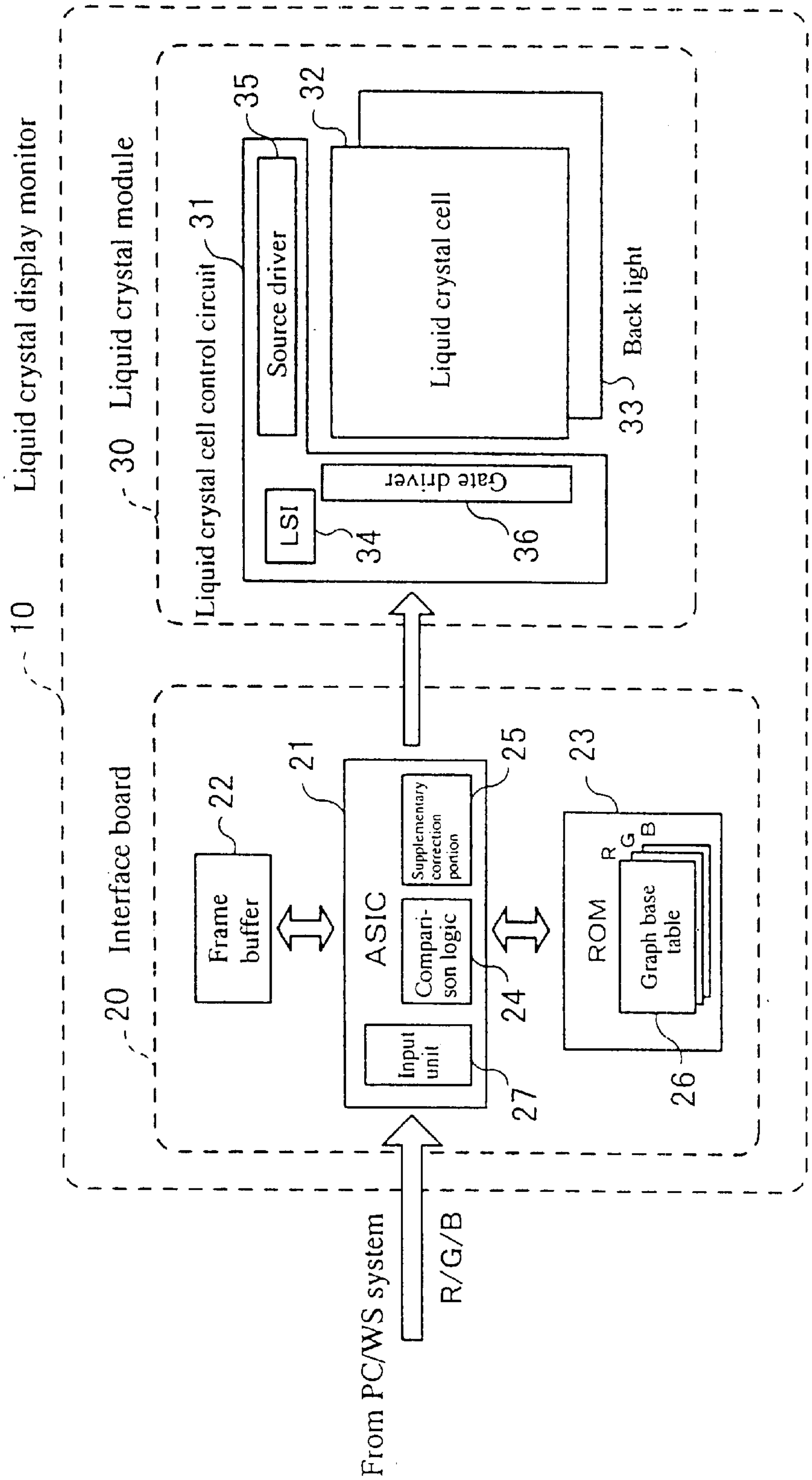
(57) **ABSTRACT**

A liquid crystal display comprises an input for inputting a video signal from a host and a storage medium for storing the previous brightness level of the video signal input through the input. A determinator is provided for determining an output brightness level based on the previous brightness level stored in the storage medium and the next brightness level of the next video signal input to the input, so as to make the time integration quantity of a brightness change substantially equal to an ideal quantity of light in a stationary state with respect to the next brightness level. Further included are drivers for driving an image displaying liquid crystal cell based on the output brightness level determined by the determinator.

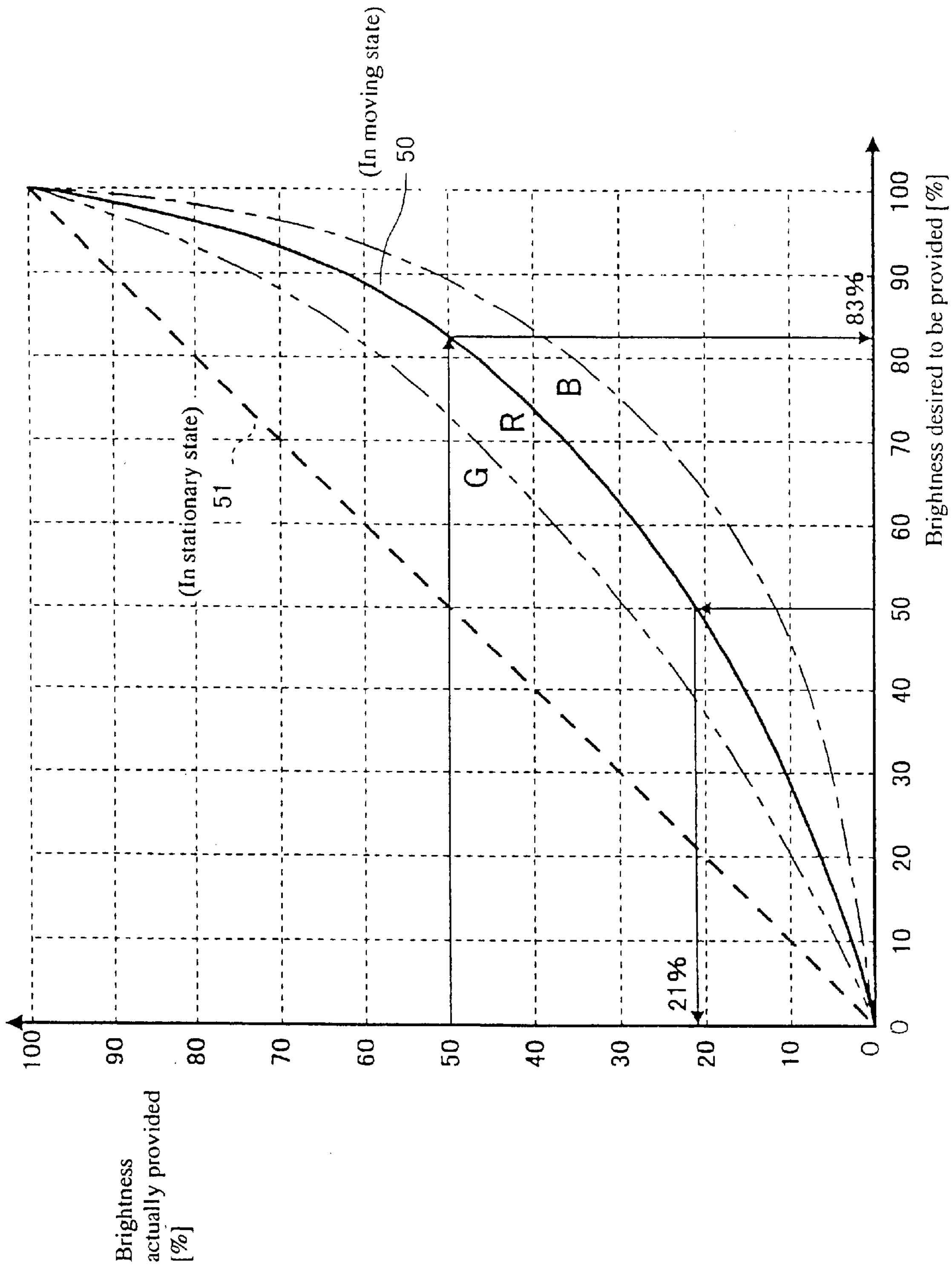
14 Claims, 11 Drawing Sheets



[Figure 1]


Liquid crystal display monitor
10
30 Liquid crystal module
Liquid crystal cell control circuit
31
35
Source driver
32
Liquid crystal cell
33 Back light
LSI
34
Gate driver
36
20 Interface board
22
Frame buffer
21
ASIC
Input unit
27
Compari-son logic
24
Supplementary correction portion
25
23
ROM
R G B
Graph base table
26
From PC/WS system
R/G/B

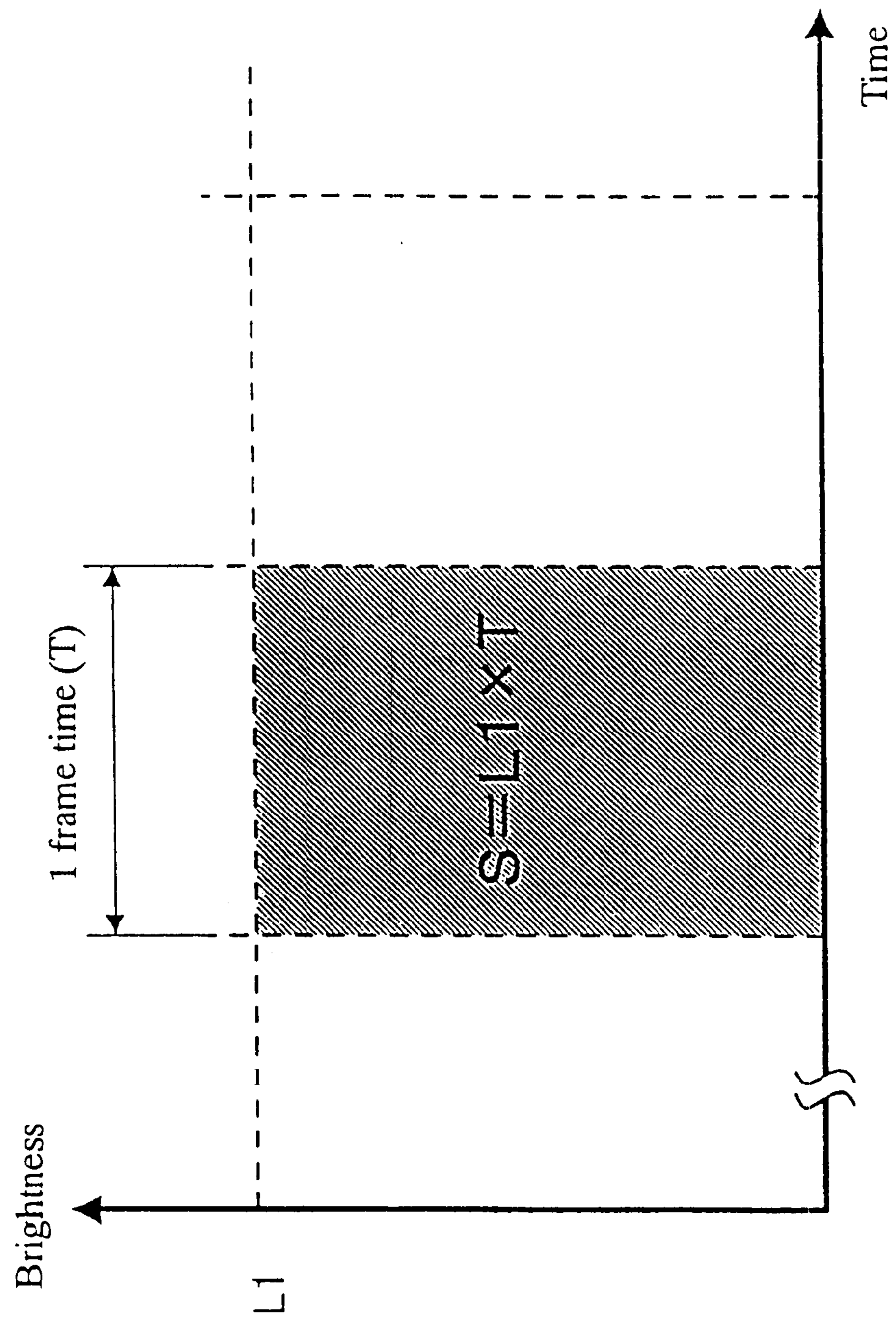
[Figure 2]


(In moving state)
50
(In stationary state)
51
G
R
B
83%
21%
Brightness desired to be provided [%]
Brightness actually provided [%]
0
10
20
30
40
50
60
70
80
90
100

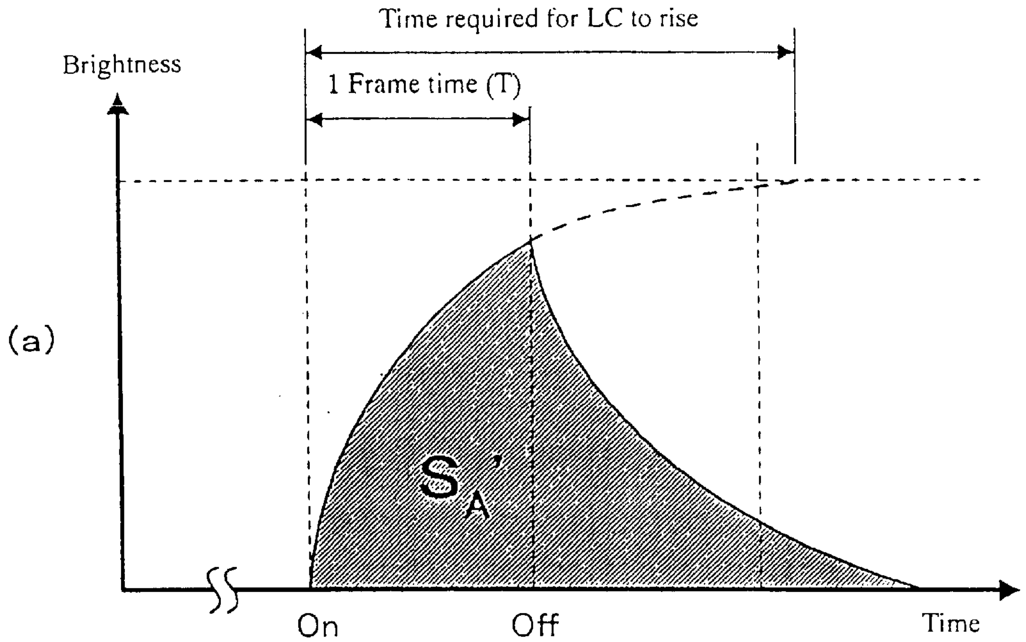
[Figure 3]

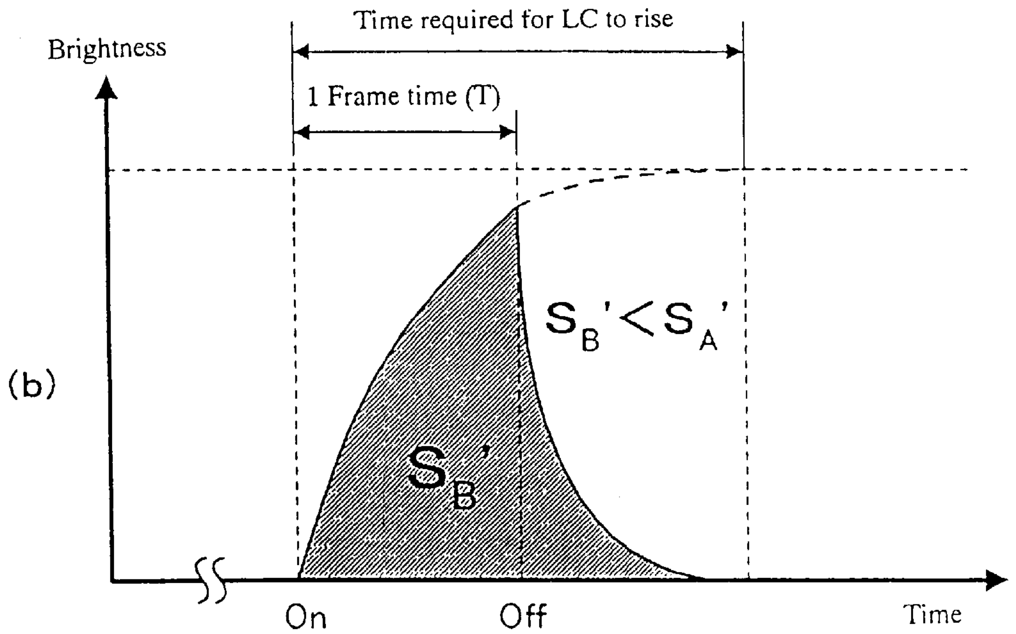
Model (Magnitude of flicker)	Response rising time	Response falling time	Light quantity ratio (to ideal LC)	Brightness ratio of drawing in moving state to that in stationary state
Model A (○)	20. 3ms	21. 6ms	1. 02 : 1	1. 0 : 1
Model B (×)	18. 5ms	10. 0ms	0. 81 : 1	0. 8 : 1
Model C (△)	10. 0ms	4. 5ms	0. 85 : 1	0. 9 : 1
Model D (×)	19. 9ms	7. 9ms	0. 73 : 1	0. 7 : 1
Model E (×)	43. 2ms	34. 3ms	0. 53 : 1	0. 3 : 1

[Figure 4]

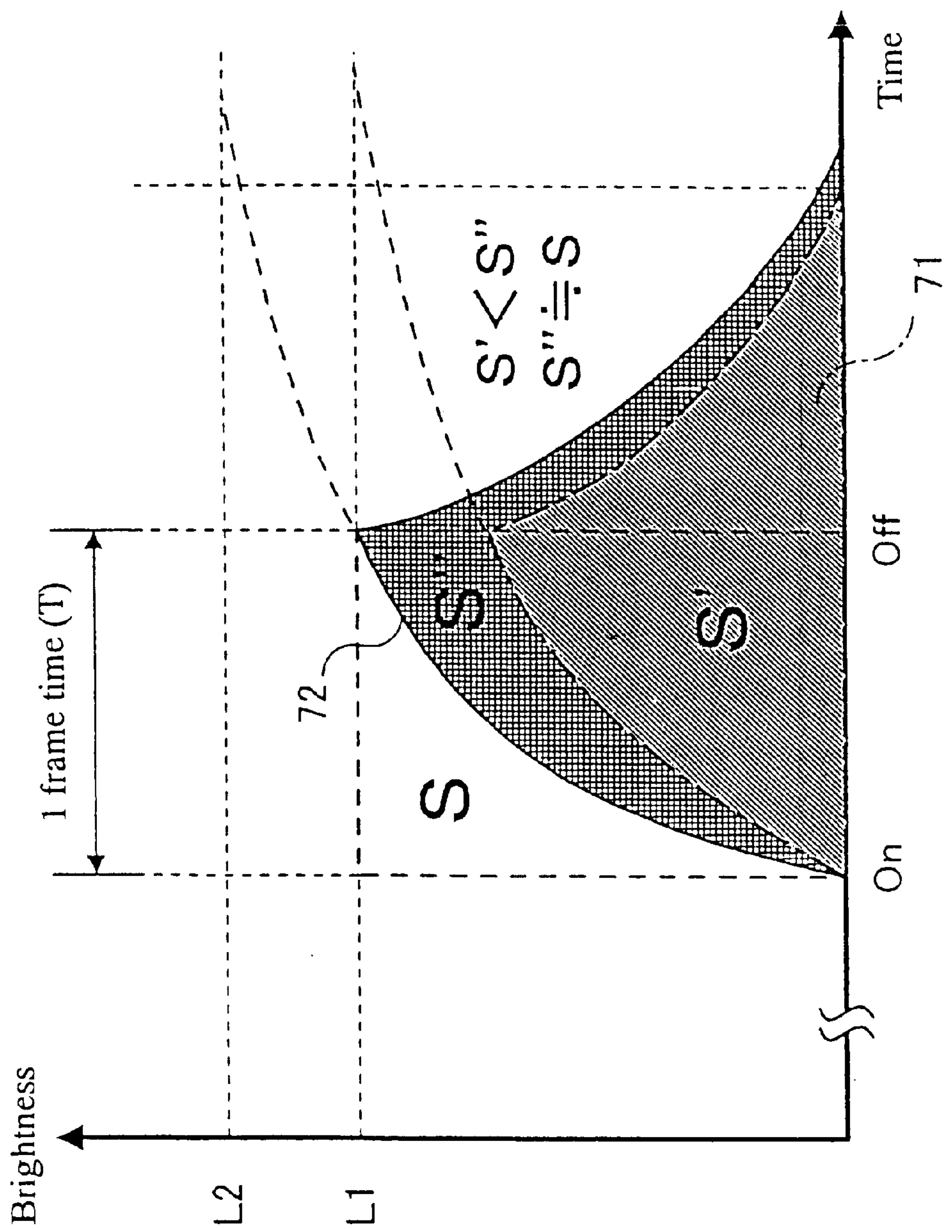


[Figure 5]


Time required for LC to rise
Brightness
1 Frame time (T)
(a)
S_A'
On
Off
Time


Time required for LC to rise
Brightness
1 Frame time (T)
$S_B' < S_A'$
(b)
S_B'
On
Off
Time

[Figure 6]

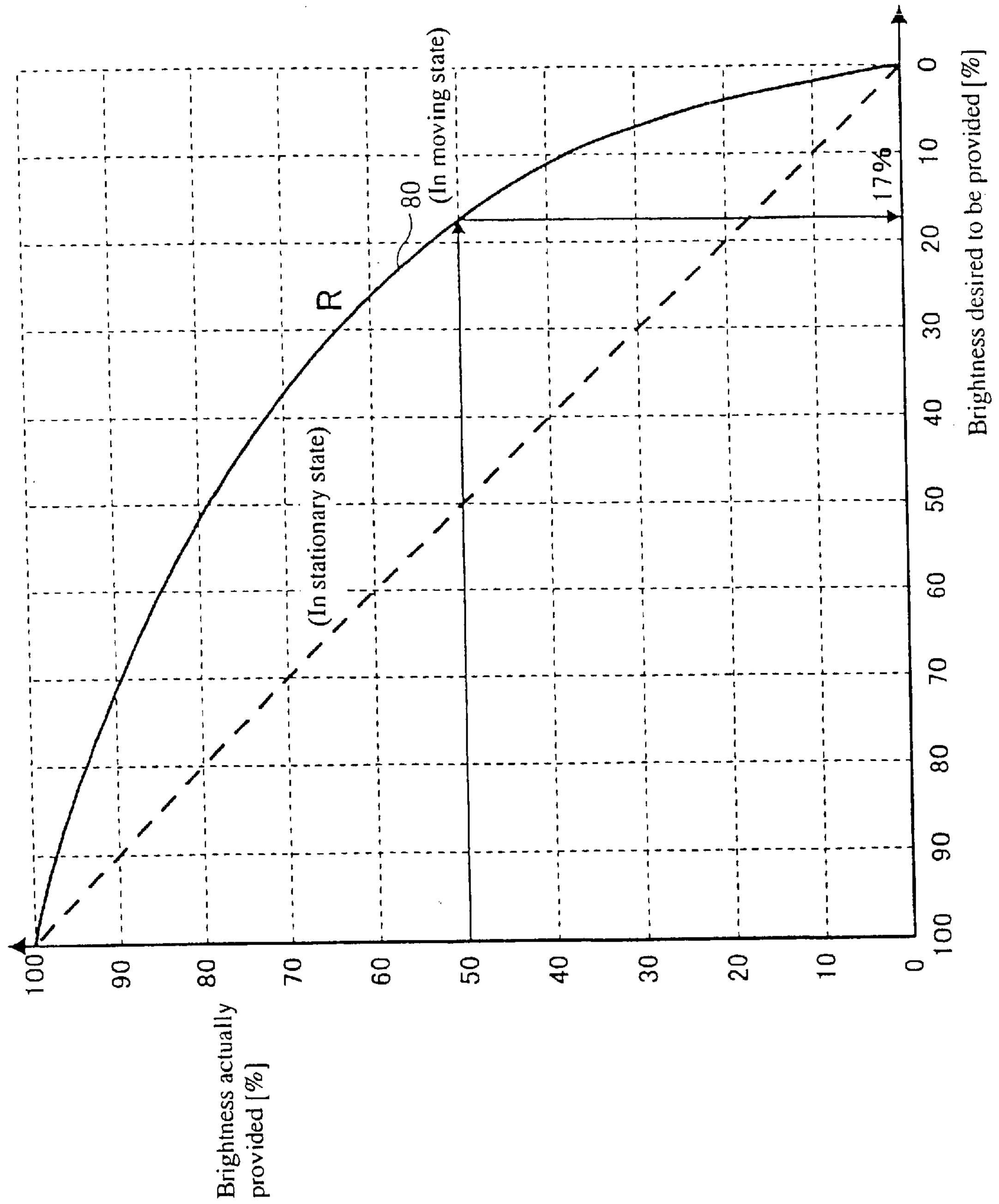


[Figure 7]

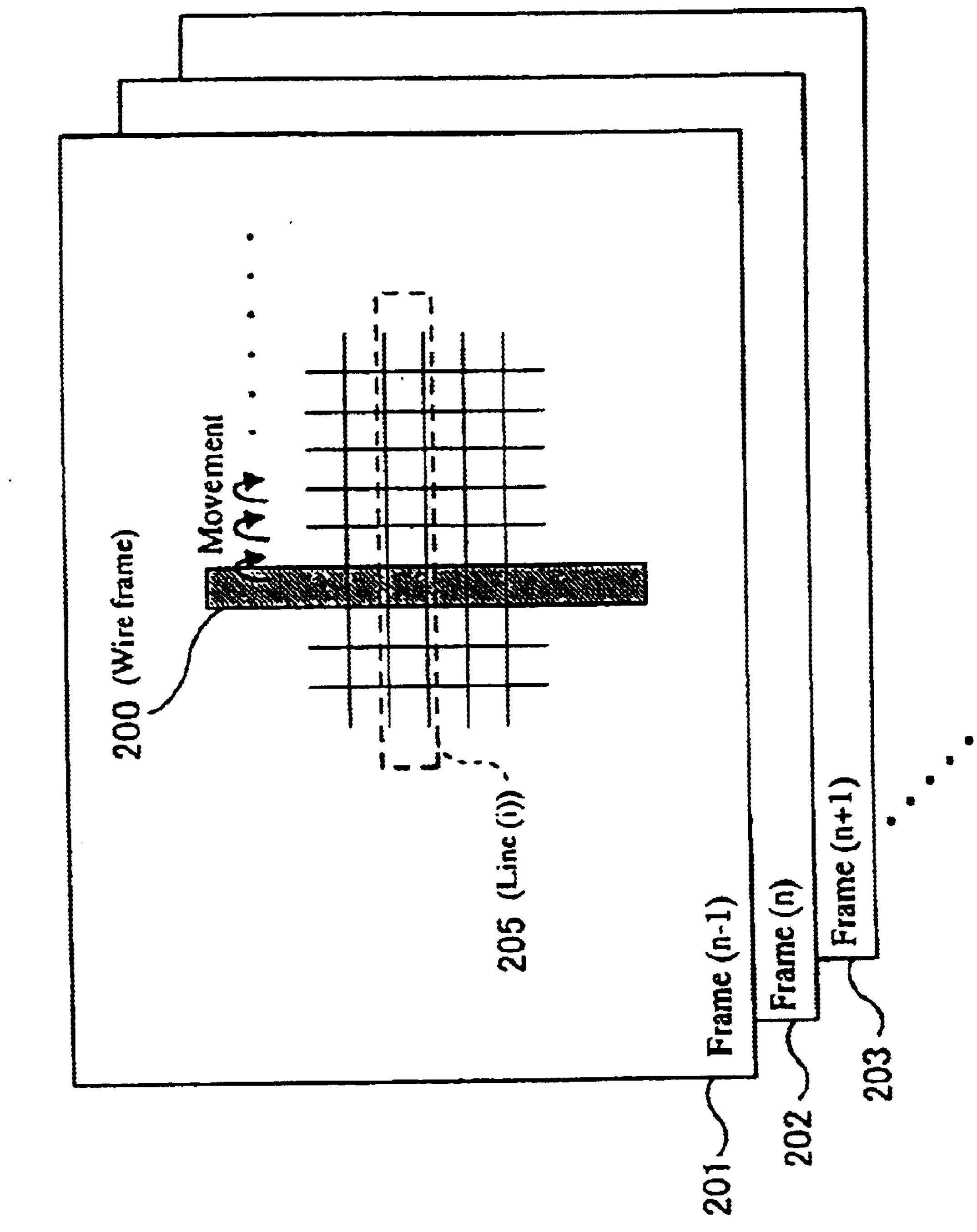
26 (Graph base table)

Previous brightness \ Next brightness	0	10	20	30	40	50	60	70	80	90	100
0	0	28	48	63	74	83	88	93	96	98	100
10	0	10	30	45	56	65	70	75	80	90	100
20	0	10	20	35	46	55	60	70	80	90	100
30	0	10	20	30	41	50	60	70	80	90	100
40	0	10	20	30	40	50	60	70	80	90	100
50	0	10	20	30	40	50	60	70	80	90	100
60	0	10	20	30	40	50	60	70	80	90	100
70	0	10	20	30	40	50	59	70	80	90	100
80	0	10	20	30	40	45	54	65	80	90	100
90	0	10	20	25	30	35	44	55	70	90	100
100	0	2	4	7	12	17	26	38	52	72	100

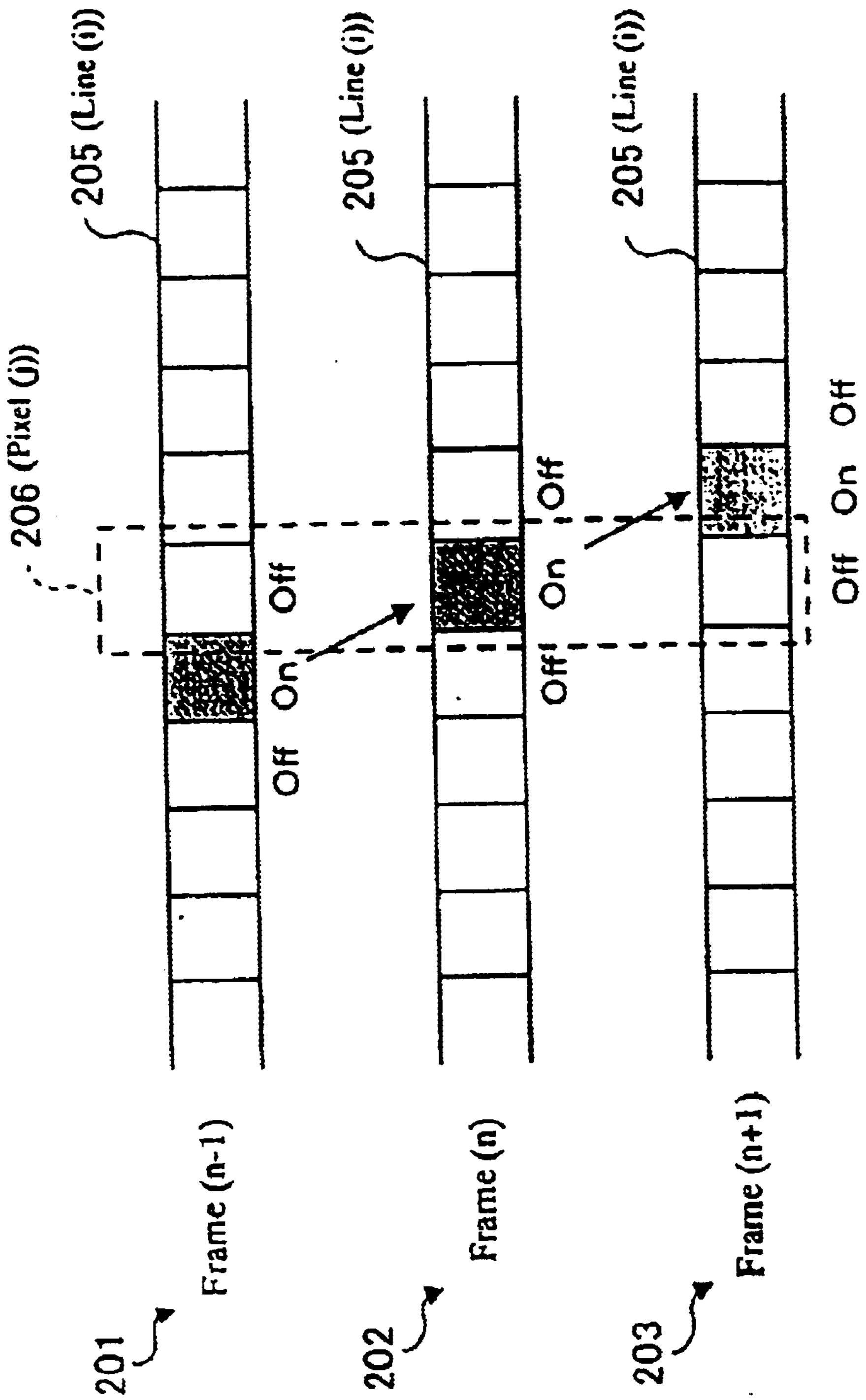
[Figure 8]


Brightness desired to be provided [%]
Brightness actually provided [%]
(In moving state)
(In stationary state)
80
R
17%
0
10
20
30
40
50
60
70
80
90
100

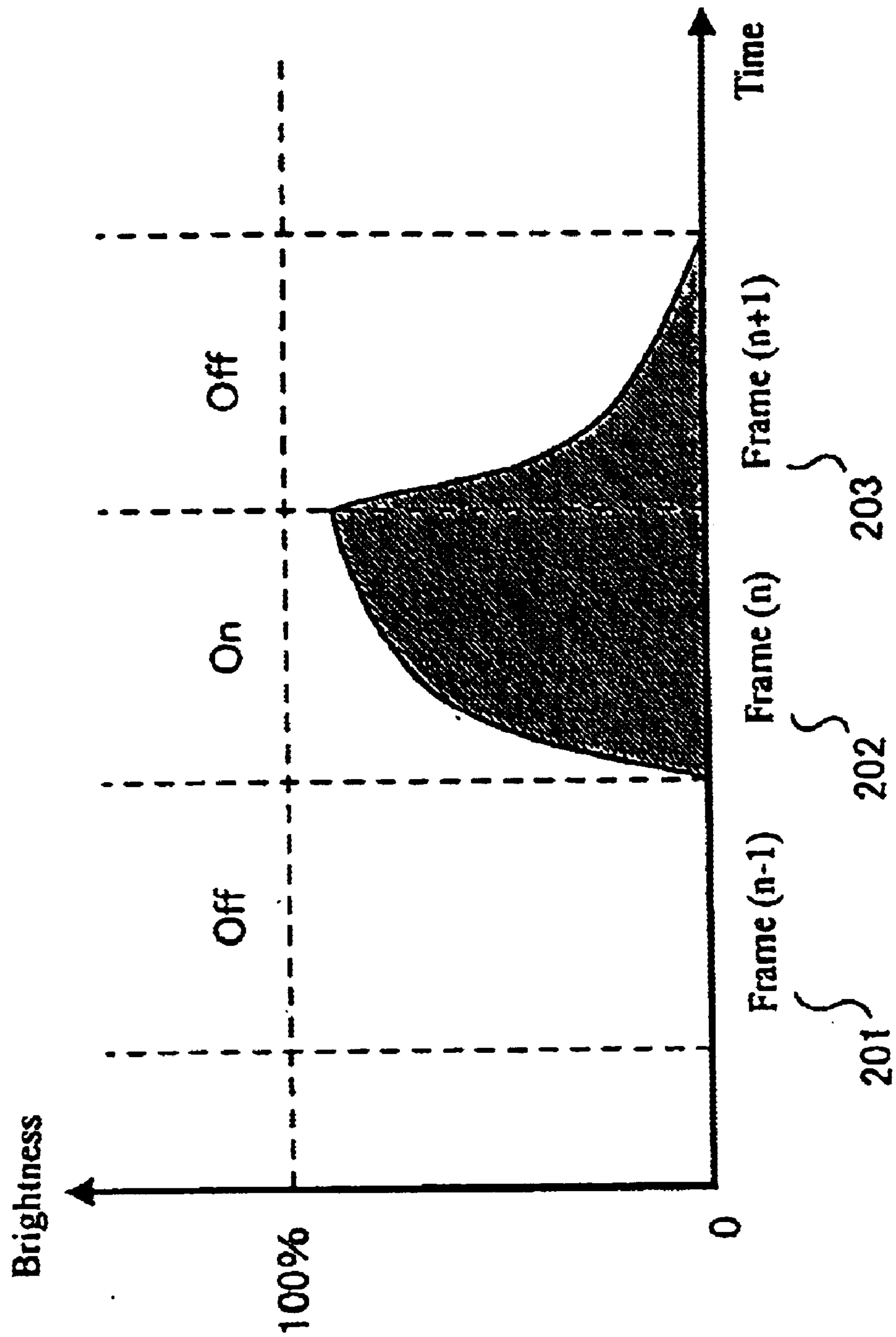
[Figure 9] PRIOR ART



[Figure 10] PRIOR ART



[Figure 11] PRIOR ART



LIQUID-CRYSTAL DISPLAY, LIQUID-CRYSTAL CONTROL CIRCUIT, FLICKER INHIBITION METHOD, AND LIQUID-CRYSTAL DRIVING METHOD

FIELD OF THE INVENTION

The present invention relates to a method for compensating poor response time, and in particular, to a method and an apparatus for inhibiting flicker resulting from the poor response time of a liquid crystal display.

BACKGROUND OF THE INVENTION

In recent years, besides cathode ray tubes (CRTs), liquid crystal displays (LCDs) have come into widespread use as display devices for various types of image displays and monitors for units such as personal computers (PCs) and television sets. The LCDs can be made significantly smaller and lighter than CRTs. In addition, many improvements in the display performance of LCDs, including low geometric distortion as well as considerably high picture quality, have been achieved. For these reasons, the LCDs have gained the spotlight as a mainstream display device used in video equipment of the future.

However, because of the poor response characteristic of the liquid crystal itself, the LCDs has the potential problem of poor response time. That is, in a typical display device used in the industry, the display is refreshed at a frame rate of 60 frames per minute, or, every (1÷60=) 16.7 ms. On the other hand, the response time of liquid crystals used in many current LCDs required to change from black to white is 10 to 50 ms, typically 20 to 30 ms. This means that one frame time in the display is shorter than the response time of most liquid crystals. As a result, problems, such as the visual persistence of moving images and inability to keep up with fast-moving images, caused by the response delay of the LCDs have become obvious.

The term "response time" used in the industry refers to the sum of (1) time required to reverse color by applying a voltage to a liquid crystal cell and (2) time required to restore the original color by the removal of the applied voltage. The term "frame" used in the industry represents the scanning of all the images (picture elements) that should form one complete picture on the display.

Some solutions to these poor response time problems with the LCD are disclosed in, for example, Published Unexamined Japanese Patent Applications Nos. 2-153687, 4-365094, 6-62355, and 7-56532.

In Published Unexamined Japanese Patent Application No. 2-153687, a LCD is provided which is configured to discriminate between a static image area having less motion and a fast-moving area and apply a signal process only to the moving area to emphasize time-based changes in an image, thereby improving response time in the image area where better response time is required to reduce visual persistence and noise.

In Published Unexamined Japanese Patent Application No. 4-365094, a LCD is provided which is configured to be driven by reading pre-stored optimum image data according to the direction and degree of a change when the image data changes, thereby allowing the LCD to rapidly follow the fast-changing image.

In Published Unexamined Japanese Patent Application No. 6-62355, a technology is disclosed which superposes a difference component between fields or frames on a video signal to provide pulse stepping drive when the video signal changes between the fields or frames, thereby improving the response of display elements in an LCD.

In Published Unexamined Japanese Patent Application No. 7-56532, a technology is disclosed which provides table memory containing a table of image increase/decrease values and drive a liquid crystal panel (liquid crystal cell) by performing an addition/subtraction in order to improve response changes due to changes in the gray scale in the liquid crystal panel. However, the amount to be added or subtracted is expressed only by the word "optimum" and no specific amount is disclosed.

One problem associated with picture quality in LCDs which do not arise in a CRT display is flicker. When, for example, a wire-frame model in a CAD application is displayed on the LCD and the operator (user) moves it continuously at a relatively low speed, about several tens pixels per minute, the entire wire-frame model appears to blink in a cycle of several to several tens Hz. This effect is called flicker. While this effect does not occur in CRT displays, it occurs in most existing types of LCDs and many customers have requested minimization of the flicker urgingly. The flicker herein differs in symptom and cause from that in CRT displays which is caused by infrequent refresh.

In CAD applications, a wire-frame model is typically displayed using many thin lines in white or other colors against a black background. Assuming that the wire-model is white (all of the colors R (read)/G (green)/B (blue) are "ON") as an example, no problem arises when the model stay stationary on the screen because only a few frames are required to achieve an proper brightness. However, if the operator move the model on the screen, the proper brightness cannot completely be achieved. That is, if a pixel is made light up only in one frame, the brightness of the pixel may not reach the predetermined brightness because the response of the LCD itself is slow as mentioned above. This situation will be described below with reference to the drawings.

FIG. **9** shows the movement of lines when a wire-frame model is moved on the screen. FIG. **10** shows on/off states of the pixels on line (i) in each frame at the time point in FIG. **9**. FIG. **11** shows a change in the brightness of pixel (j).

Herein, as shown in FIG. **9**, in the case where attention is paid to a particular pixel, assuming that a line of the wire frame **200** moves through frames (n−1) **201** to (n) **202** to (n+1) **203** in sequence. That is, the pixel lights up in a time period equivalent to the frames in which the line passes over the pixel and goes off immediately after that.

Focusing attention on line (i) **205** represented by a dashed line, in particular, on the particular pixel, each frame is driven from OFF to ON by the movement of pixel (j) **206**, then one frame after goes back from ON to OFF, as shown in FIG. **10**. However, because the response time of commonly-used liquid crystals is longer than 16.7 ms, pixel (j) **206** changes back to black before completely returning from black to white. That is, as shown in FIG. **11**, pixel (j) **206** is OFF in frame (n−1) **201**, goes ON in frame (n) **202**, then goes OFF in frame (n+1) **203**. However, the target brightness of pixel (j) **206** is not reached even though it is turned on in order to achieve 100% brightness in frame (n) **202**. As a result, the brightness of the line drawing during movement will be low. The inventors have found that when a wire-frame model is continuously moved in a CAD application, the wire-frame model in fact repeatedly alternates between moving and stationary states every several frames and blinks due to a difference in display brightness

between the moving and stationary states, and this difference causes "flicker."

Many manufacturers have actively sought after a method for improving the response of LCD panels by improving a liquid crystal material itself or narrowing the gap between glass plates in order to reduce flicker of LCDs. Some state-of-the-art products on the market have an improved response time of about 25 ms including rising and falling time. Another LCD technologies for reducing response time to several ms have been disclosed in some academic conferences. However, these approaches to improve an LCD panel itself can hardly to provide mass-production products because of their low reliability, and there are many other problems to be solved to put them into practical use.

In view of these technical problems, it is a primal object of the present invention to inhibit the flicker effect as visual perception by the panel driving circuitry which drives an LCD.

It is another object of the present invention to drive the LCD by applying an offset to a moving model without globally determining whether the model is moving or stationary.

SUMMARY OF THE INVENTION

To achieve above-mentioned objects, a feature of the present invention includes a liquid crystal display comprises an input for inputting a video signal from a host and a storage medium for storing the previous brightness level of the video signal input through the input. A determinator is provided for determining an output brightness level based on the previous brightness level stored in the storage medium and the next brightness level of the next video signal input to the input, so as to make the time integration quantity of a brightness change substantially equal to an ideal quantity of light in a stationary state with respect to the next brightness level. Further included are drivers for driving an image displaying liquid crystal cell based on the output brightness level determined by the determinator.

Another feature of the present invention includes a liquid crystal display characterized by comprising a driver for driving each of the pixels forming an image for each frame to a liquid crystal cell displaying the image, an input for inputting an moving-state video signal which changes from the off state to the on state on transition to a particular frame in the frames and returns to the off state after the particular frame is completed, and elements for setting an offset for making the quantity of light closer to the quantity of light in a stationary state in which the moving-state video signal is continuously turned on for the particular frame. The liquid crystal display further includes a generator for applying the offset set by the setting elements to the moving-state video signal input through the input means to generate an output video signal, and an output for outputting the output video signal generated by the generation means to the drive means. By configuring the apparatus in this way, a difference in brightness between a stationary state and a moving state which can be considered as the principal cause of flicker can be reduced to inhibit visually perceptible flicker.

Yet another feature of the present invention is further characterized by a liquid crystal control circuit having a function for inhibiting flicker caused by a difference in brightness when an input wire-frame model is displayed by liquid crystal cells. The liquid crystal control circuit includes a storage portion for storing an offset in brightness in a moving state in which the wire-frame model having a predetermined gray scale changes from frame to frame with respect to a particular pixel. This is with relation to brightness output in a stationary state in which the wire-frame model having the predetermined gray scale is displayed on the particular pixel across a plurality of frames. Further included is a correction portion for applying the offset stored in the storage portion to the gray scale of the wire-frame model if the input wire-frame model is in a moving state.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram for showing the overall configuration of a liquid crystal display (LCD) apparatus according to one embodiment of the present invention.

FIG. **2** is a graph showing an example of brightness of a wire-frame image in a moving state on the LCD used with the embodiment.

FIG. **3** is a table showing the measurements of response time at the maximum brightness of a liquid crystal used in five LCD models (model A to E).

FIG. **4** shows the response characteristic of an ideal liquid crystal.

FIGS. **5** (*a*) and (*b*) are graph showing the response characteristics of models A and B shown in FIG. **3** by brightness versus time when a pixel is turned on for only one frame.

FIG. **6** shows an effect when brightness is set by taking a required offset into consideration.

FIG. **7** shows a relation between brightness L1 and brightness L2 in table form;

FIG. **8** is a graph showing desired brightness versus brightness actually provided when brightness falls.

FIG. **9** shows the movement of a line on the screen when a wire-frame model is moved on the screen.

FIG. **10** shows the ON/OFF states of a pixel on line (i) in each frame.

FIG. **11** shows changes in brightness of pixel (i).

DETAILED DESCRIPTION OF THE INVENTION

The "ideal quantity of light" herein is, to take an example, the quantity of light based on a response characteristic which provides a target brightness level at a time point at which the frame is turned on and provides a brightness level of zero at the time point at which the frame is turned off on a display device in which each pixel is driven for each frame. The brightness level can be represented as a target brightness value by a gray scale and considered as an indication of the characteristic of human visual sensation to brightness. In addition, a brightness change can be considered as a response characteristic depending on the types of liquid crystal cells (liquid crystal panels). Quantity of light is considered as a time integration quantity of a brightness change and can be expressed as brightness_time, if the brightness is constant. The representation "substantially equal level" refers to a level which is not completely the same but can be accepted as a substantially equivalent level, and includes a level which is closer to an ideal quantity of light than no preventive measures are taken.

The determinator is characterized by comprising a table for storing a brightness level determined by the characteristic of a liquid crystal cell according to a relation between the previous brightness level and the next brightness level, and determining an output brightness level by modifying the next brightness level based on the brightness level read from the table. With this configuration, flicker due to changes in

the quantity of light during the movement of the model can be inhibited without globally determining whether a model is in a moving or stationary states. In addition, a correction for a "halftone" can be made, thereby allowing a decrease in brightness level, which is remarkable in halftones, to be addressed properly.

The video signal input through the input consists of a plurality of color signals and the table in the determinator is provided for each of the color signals so that a brightness level correction for each color can be made with respect to flicker perception of the human eye to reduce a difference in brightness, thereby an easy-on-the-eye liquid crystal display can be provided to the user. While the color signals may be R (read), G (green), B (blue) signals used in displays, other display systems can also be used.

The offset set by the setting elements can be determined based on a time integration quantity, which is a change in brightness in the moving-state vide signal integrated with respect to time, and the quantity of light in stationary state, thus a difference in brightness can be preferably reduced in consideration of the human visual perception characteristic to inhibit flicker appropriately.

The moving-state video signal passed through the input consists of a plurality of color signals, the offset set by the setting elements is determined for each of the color signals, and the generator generates the output video signal for each color signal based on the offset determined for each color signal. Thus a difference in brightness between moving and stationary states can be corrected for each color signal to inhibit flicker on a color image display.

The apparatus further comprises a frame buffer for storing the brightness information of the input wire-frame model as the previous brightness, and characterized by that the storage portion stores the offset as table information based on a relation between the previous brightness stored in the frame buffer and the brightness of the next input wire-frame model, thus, flicker in a moving state can be advantageously inhibited without providing separate determining units for moving and stationary states.

Because the wire-frame model in the present invention is a model consisting of a large number of thin lines in white or other colors in a CAD application, for example, in which flicker is especially troublesome, the flicker inhibition by correcting gray scale of such a wire-frame model in a moving state is highly effective.

The liquid crystal control circuit may be implemented as an interface board provided in a liquid crystal display monitor. The liquid crystal display monitor may be one used with a desktop personal computer or a CAD computer as well as one integrated with a host, like a notebook computer.

In another category, the present invention is a flicker inhibition method for inhibiting flicker caused by a difference in brightness when an input wire-frame model is displayed by a liquid crystal cell. The method is characterized by storing a relation between brightness in a stationary state in which a wire-frame model having a predetermined gray scale is displayed on a particular pixel across a plurality of frames and brightness in a moving state in which the wire-frame model having the predetermined gray scale changes frame to frame with respect to the particular pixel, applying an offset based on the stored relation to the gray scale of the wire-frame model if the input wire-frame model is in a moving state, and driving the liquid crystal cell based on the gray scale to which the offset is applied to display the wire-frame model.

The moving state brightness used for storing the relation is the brightness when the particular pixel changes back to the off state one frame after it is driven from the off state to the on state during the passage of the wire-frame model over the particular pixel.

Furthermore, the brightness in the moving state which is used when the relation is stored is the quantity of light equal to the brightness change integrated with respect to time.

With this configuration, a difference in the brightness of the wire-frame model between its moving state and stationary state can be reduced to inhibit flicker which would otherwise noticeably occur.

Viewing the present invention as a liquid crystal driving method, the liquid crystal driving method of the present invention is characterized by the steps of storing first brightness information for an input pixel in a frame buffer, and applying, based on second brightness information for the next input pixel and the first brightness information stored in the frame buffer, an offset for making the time integration quantity of a brightness change substantially equal to an ideal light quantity which is brightness in a stationary state to the second brightness information. The steps further include the outputting of the second brightness information to which the offset is applied to a driving circuit for driving an liquid crystal cell, and storing the second brightness information for the input pixel in a frame buffer. This liquid crystal driving method allows the inhibition of flicker by using a simple apparatus without globally determining whether a model is moving or stationary.

The present invention is still further characterized in that the input pixel consists of a plurality color signals and includes the step of storing the first brightness information in the frame buffer stores the first brightness information for each of the color signals, and the step of applying the offset applies the offset to each of the color signals, thus the brightness of each color of a color image consisting of a plurality of color signals can be corrected individually, allowing more adequate flicker inhibition.

The offset applying step is characterized by the step of reading a pre-stored offset based on the relation between the first and second brightness information and applying the read offset to the second brightness information.

The brightness information at a moving time that is used in a storage operation based on the relation is the quantity of light equal to a brightness change for each color signal integrated with respect to time, therefore correction according to the human visual perception characteristics can be made to address the problems resulting from human visual perception of flicker more properly.

The present invention will be described below with respect to the embodiments shown in the accompanying drawings.

FIG. **1** is a drawing for showing the overall configuration of a liquid crystal display according to an embodiment of the present invention. Reference number **10** denotes a liquid crystal display monitor (LCD monitor) as a liquid crystal display panel, which comprises, for example, a liquid crystal module **30** having a thin-film transistor (TFT) structure and an interface (I/F) board **20** connected to a digital or analog interface to a personal computer (PC) or a workstation (WS) system for supplying a video signal to the liquid crystal module **30**. If a notebook PC is used, a system unit (not shown) is integrated with the liquid crystal display monitor **10**. If a monitor having a display device separated from its system unit is configured, a system unit (not shown) is attached to the LCD monitor **10** to form a liquid crystal display.

The I/F board **20** comprises a input unit **27** for inputting video data from a host such as a PC/WS system, a com-

parison logic **24** for comparing the previous brightness with the next brightness for an input video signal, and an Application-Specific Integrate Circuit (ASIC) **21** including a logic having units such as a supplementary correction portion **25** for performing a supplementary correction. The I/F board **20** also comprises a frame buffer **22** for temporarily storing the input video signal and read-only memory (ROM) **23** containing information needed for the operation of the ASIC **21**. The frame buffer **22** stores input video signal value input previously and provides it to the ASIC **21**. The ROM **23** includes a graph base table **26** which is required for the supplementary correction in the ASIC **21** and is set for each of R/G/B input color signals. The graph base table **26** contains a brightness level to be output based on a relation between the previous brightness and the next brightness in a table form which will be described later.

The liquid crystal module **30** consists of three main blocks a liquid cell control circuit **31**, liquid crystal cell **32**, and a backlight **33**. The liquid cell control circuit **31** consists of panel drivers such as an LCD controller LSI **34**, a source driver (X driver) **35**, and a gate driver (Y driver) **36**. The LCD controller LSI **34** processes signals received from the I/F board **20** via a video interface and outputs appropriate signals to each ICs of the source driver **35** and gate driver **36** with an appropriate timing. The liquid crystal cell **32** outputs an image using a TFT array arranged in a matrix through the application of a voltage from the source driver **35** and the gate driver **36**. The backlight **33** has a fluorescent tube (not shown) located on the back or side of the LC cell **32** for illuminating the cells from the back.

FIG. **2** is a graph showing an example of the brightness of a wire-frame model moving on the LCD panel used in this embodiment. The horizontal scale indicates brightness (%) desired to be provided and the vertical scale indicates brightness (%) actually provided in the Figure. The dashed line **51** indicates the relationship between the desired brightness and actual brightness of the model in a stationary state. The solid line **50** indicates the relationship between the desired brightness and actual brightness of the model in a moving state for an R (red) signal. The alternate long and short two dashes line indicates a G (green) signal in the moving state and the alternate long and short one dash line indicates a B (blue) signal in the moving state. The characteristics in the moving state vary from LCD panel to LCD panel.

Consider the case where a wire-frame model of a halftone, which is 50% brightness, is displayed on the LCD having the characteristics shown in FIG. **2**. In the stationary state **51**, there is no problem because the 50% brightness of a pixel can be achieved with some frames by driving the liquid crystal with a voltage providing the 50% brightness. On the other hand, in the moving state, as apparent from the line **50** indicating the brightness for the R signal in moving state, actually only 21% brightness can be obtained on the display even by driving the liquid crystal with a voltage equivalent to 50% brightness. To achieve an actual brightness of 50%, the LC must be driven with an voltage equivalent to 83% brightness. That is, an offset of 33% is required to be applied to the input voltage equivalent to 50% brightness. For the B signal, more offset is required. Though the brightness for G signal is somewhat closer to that in the stationary state **51**, an offset is still required to be applied.

The relationship between the response characteristic of liquid crystal and flicker will be further discussed below.

FIG. **3** is a table showing the measurements of the response time of liquid crystal at the maximum brightness in five LCD models (models A to E). In a model **61** shown in the first column, the symbol in parentheses indicates the magnitude of flicker at the maximum brightness. Symbol "○" indicates that almost no flicker is visually perceived, symbol "Δ" indicates that flicker level is quite acceptable, and symbol "X" indicates that intensive flicker is perceived. Response rising time **62** is shown in the second column and response falling time **63** is shown in the third column. The light quantity ratio **64** in the forth column represents the ratio of the light quantity of each model to that of an ideal LC. The ratio of the brightness of the drawing in a moving state to that in a stationary state **65** is indicated in the fifth column. The brightness ratio of the drawing in moving state to that in stationary state **65** represents to what degree the brightness of the wire-frame model in the moving state is darkened compared to the brightness of that in the stationary state. It can be seen that while there is almost no reduction in brightness in model A (1.0:1), brightness is reduced in models B (0.8:1), D (0.7:1), and E (0.3:1), on which flicker is perceived.

In terms of whether the response at the maximum brightness is adequately fast, both of the response rising time **62** and the falling time **63** of model A is poor compared to model B. However, when a wire-frame model in an actual CAD application is displayed and moved on these LCD models, flicker in model A is less than in model B. The reason can be explained by considering the characteristics of human visual perception. It is known that the human visual perception is subject to a time integration effect ("Handbook of information technology for television image", 1st edition, pp.39–40, Institute of Television Engineers of Japan, 1990). Brightness of a pixel to the human eye cannot be considered in terms of time required to reach a specified brightness, instead, it should be considered in terms of the quantity of light, that is, a brightness change integrated with respect to time.

FIG. **4** shows the response characteristic of an ideal liquid crystal and indicates the state in which a particular pixel is kept lit up at a brightness of L**1**, that is in a stationary state. Here, the quantity of light (S) emitted in one frame time (T) is equal to L1×T (i.e. brightness×time) as shown in the shaded area in FIG. **4**.

FIGS. **5**A and **5**B show the response characteristic represented by brightness versus time when a pixel stays lit up for one frame time (On→Off) in models A, B shown in FIG. **3**. Both of the rising and falling of the response of model A shown in FIG. **5**A are gradually. As a result, the quantity of light (S_A') which is almost the same as that in the ideal LC shown in FIG. **4** can be obtained ($S_A' \approx S$). On the other hand, even though the response rising of model B is rapid, the falling is also rapid and steep as shown in FIG. **5**B. Accordingly, quantity of light S_B' is only 81% of that of the ideal LC as shown the column "Light quantity ratio" **64** in FIG. **3**. Therefore, even though the response time of model B is better than that shown in FIG. **5**A, there is a difference in brightness (the brightness in model B is less than model A) due to the difference in light quantity ($S_B' < S_A'$) in stationary/moving states, causing flicker when the wire-frame model is moved on model B. As can be seen from the results for models C, D, E in FIG. **3**, displays providing a smaller light quantity ratio **64** provide a smaller brightness ratio **65** of a drawing in a moving state to that in a stationary state, resulting in more flicker.

Although the ultimate solution to these problems is to develop an LC device having an ideal response characteristic as shown in FIG. **4**, it will be some time before such a device comes into use. Thus, another solution is required for inhibiting flicker even in LC devices having moderate response time.

One of the effective solutions may be a method that uses the measurement of a brightness difference between the stationary state **51** and moving state **50** as shown in FIG. **2**. That is, a wire-frame model is drawn with an adequate gray scale by taking account of a required offset, which can be read from the graph shown in FIG. **2**, during the movement of the wire-frame model.

FIG. **6** shows an effect when brightness is set by taking a required offset into account. If the liquid crystal is driven trying to achieve desired brightness L1 as target, only the quantity of light (S') indicated by reference number **71** can be obtained due to the response time of the liquid crystal described above. The quantity of light (S') **71** is much smaller than the quantity of light (S) provided by the ideal response characteristic shown in FIG. **4**. On the other hand, if the liquid crystal is driven with the aim of achieving brightness L2 which is larger than the desired brightness of L1, the quantity of light (S") indicated by reference number **72** can be obtained. By overdriving the LC to brightness L2, the LC reaches L1 in a short response time and the quantity of light (S") **72** can be obtained which is approximately the same as the quantity of light (S), which would be provided with the ideal response characteristic (S"≈S). Here, optimum brightness L2 with respect to L1 can be obtained from the data shown in FIG. **2**.

FIG. **7** is a table showing a relation between brightness L1 and L2 and represents the content of the graph base table **26** stored in the ROM **23** shown in FIG. **1**. The content of the graph base table **26** shown in FIG. **7** represents a relation between the previous brightness and the next brightness for the LC cell **32** having the characteristic shown in FIG. **2**, by taking the effect shown in FIG. **6** into consideration. The previous brightness can be obtained from a video signal input through the ASIC**21** shown in FIG. **1** and stored in the frame buffer **22**. The next brightness can be obtained from the next video signal input to the ASIC **21**. The graph base table **26** is constructed for each of the R, G, B color signals and the values in the table vary depending on the characteristic of the LC cell **32**.

The first row of the graph base table **26** shown in FIG. **7** indicates brightness output for the next brightness when the previous brightness is 0 and match the readings of the R signal in the moving state line **50** in the graph shown in FIG. **2**. For example, if the next brightness is "10", find a value of 10% on the vertical scale and follow the horizontal line from that point to the point at which the line intersects the moving state line **50**, and a value 28%, which is the desired brightness, can be read. When brightness rises from a certain halftone to another halftone, the offset difference is added to the previous brightness. For example, if the previous brightness is 10 and the next brightness is 20, then (48−28)+10=30. If the next brightness is 30, then (63−28)+10 =45. Similarly, if the previous brightness is 20 and the next brightness is 30, then (63−48)+20=35. If the previous brightness is 30 and the next brightness is 40, then (74−63)+30=41. In this embodiment, if a difference between the previous brightness and the next brightness is greater than an offset, the next brightness is output without change. For example, if the previous brightness is 10 and the next brightness is 80, then the offset is (96−28)=68. If the previous brightness value, 10, is added to this offset, the result would be 78. In this case, the brightness of 80 is output in order to ensure the next brightness.

On the other hand, when brightness falls from a certain halftone to another halftone, the offset is subtracted from the previous brightness. The example in FIG. **7** shows a case where the characteristic of the LC cell **32** when brightness rises (the cell is turned on) is the same as that when the brightness falls (the cell is turned off). In this example, if the previous brightness is 100 and the next brightness is 10, the output value will be 100−98=2. The value "98" is equal to the value when the previous brightness is 0 and the next brightness is 90 in FIG. **7**. Similarly, if the previous brightness is 100 and the next brightness is 20, then 100−96=4. If the previous brightness is 90 and the next brightness is 30, then 100−75=25. The value "75" is equal to the value when the previous brightness is 10 and the next brightness is 70 in FIG. **7**. Similarly, if the previous brightness is 90 and the next brightness is 40, then 100−70=30. The value "70" is equal to the value when the previous brightness is 10 and the next brightness is 60 in FIG. **7**.

While in the table in FIG. **7** the values of previous and next brightness are indicated in increments of 10 for clarity, the table in practice is constructed to store all the combinations which can be read from measurements as shown in FIG. **2**. For example, brightness values in increments of 1 may be stored, and any other degree of precision may be chosen according to a given device. While brightness is expressed in percent figures in FIG. **7**, the expression of addresses and value stored in the table is not limited to percentage, instead, any appropriate quantized values manageable in a given circuit may be used.

FIG. **8** is a graph showing brightness desired to be provided versus brightness provided actually when brightness falls. The liquid crystal in the example in FIG. **8** has brightness which falls with exhibiting a characteristic similar to the rising characteristic shown in FIG. **2**. Accordingly, the line **80** indicating a moving state shown in FIG. **8** is the vertically-flipped curve of the line **50** in a moving state shown in FIG. **2**. Tick mark labels on the horizontal scale are also inverted. As can be seen from the graph, when the brightness actually provided is 50%, the brightness desired to be provided is 17%. This matches the value when the previous brightness is 100 and the next brightness is 50 in the table in FIG. **7**. That is, the moving state line **80** in FIG. **8** exactly indicates the fall of the previous brightness from 100% in FIG. **7**.

While the embodiment has been described with respect to the example which exhibits the same rising (from OFF to ON) and falling (from ON to Off) characteristics, these characteristics may vary depending on the types of liquid crystals. Therefore, the embodiment is configured to accommodate the variation of characteristics by modifying the values in FIG. **7** according to the characteristics of a given liquid crystal.

As described above, the embodiment is configured to store offsets in table form based on the relation between a brightness level in a stationary state and that in a moving state in order to obtain an ideal quantity of light. Thus, even during the movement of a display image on the LCD screen, the image can be displayed virtually the same brightness to the eye as in its stationary state, thereby inhibiting flicker on the screen.

In addition, the embodiment is configured to store the previous brightness level (gray scale value) in the frame buffer **22** and a supplementary correction is made by the ASIC **21** using the data in the graph base table **26** based on the relation between the brightness level of the next video data and the previous brightness level. Thus, whether a wire-frame model is moving or stationary is not required to be determined. Instead, the movement of the model can be determined from a difference between the determined brightness and the previous brightness. As a result, flicker can be inhibited by a simple circuit configuration.

Furthermore, the embodiment addresses the flicker problem resulting from the response time of the LC panel in recognition of the importance of the quantity of light (brightness×time) to visual perception. As a result, slow response of any types of liquid crystals (such as TN, IPS, and MVA) can be compensated by constructing a look-up table adapted to the characteristics of each liquid crystal. Thus, a flexible liquid crystal control circuit and liquid crystal display which can be widely used can be provided.

As described above, according to the invention, flicker of LCDs which poses a considerable problem in applications such as the display of wire-frame model can be made unperceivable to the user's eye by a simple configuration.

While this invention has been described in terms of certain embodiment thereof, it is not intended that it be limited to the above description, but rather only to the extent set forth in the following claims. The embodiments of the invention in which an exclusive property or privilege is claimed are defined in the appended claims.

We claim:

1. A liquid crystal display, comprising:

an input logic for inputting a video signal from a host;

a storage for storing the previous brightness level of the video signal input through said input logic;

a determinator for determining an output brightness level based on the previous brightness level stored in said storage and the next brightness level of the next video signal input to said input logic so as to make a time integration quantity of a brightness change substantially equal to an ideal quantity of light in a stationary state with respect to the next brightness level; and

a driver for driving an image displaying liquid crystal cell based on said output brightness level determined by said determination logic.

2. The liquid crystal display according to claim **1**, wherein said determinator comprising a table for storing a brightness level determined by the characteristic of a liquid crystal cell according to a relation between the previous brightness level and the next brightness level, and determining the output brightness level by modifying said next brightness level based on the brightness level read from said table.

3. The liquid crystal display according to claim **2**, wherein:

said video signal input through said input logic comprises a plurality of color signals; and

said table in said determinator is provided for each of said color signals.

4. A liquid crystal display, comprising:

a driver for driving each of the pixels forming an image for each frame to a liquid crystal cell displaying said image;

an input logic for inputting a moving-state video signal which changes from the on state to the off state on transition to a particular frame in said frames and returns to the off state after said particular frame is completed;

a setting logic for setting an offset for making the quantity of light closer to the quantity of light in a stationary state in which said moving-state video signal is continuously turned on for said particular frame;

a generator for applying said offset set by said setting logic to said moving-state video signal input through said input logic to generate an output video signal; and

an output logic for outputting said output video signal generated by said generator to said driver.

5. The liquid crystal display according to claim **4**, wherein said offset set by said setting logic can be determined based on a time integration quantity and the quantity of light in said stationary state, said time integration quantity being a change in brightness in said moving-state vide signal integrated with respect to time.

6. The liquid crystal display according to claim **4**, wherein:

said moving-state video signal input through said input logic comprises a plurality of color signals;

said offset set by said setting logic is determined for each of said color signals; and

said generator generates the output video signal for each color signal based on said offset determined for each color signal.

7. A liquid crystal control circuit, having a function for inhibiting flicker caused by a difference in brightness when an input wire-frame model is displayed by liquid crystal cells, comprising:

a storage portion for storing an offset in brightness in a moving state in which said wire-frame model having a predetermined gray scale changes from frame to frame with respect to a particular pixel, with relation to brightness output in a stationary state in which the wire-frame model having the predetermined gray scale is displayed on the particular pixel across a plurality of frames; and

a correction portion for applying said offset stored in said storage portion to the gray scale of the wire-frame model if said input wire-frame model is in a moving state.

8. The liquid crystal control circuit according to claim **7**, further comprising a frame buffer for storing the brightness information of said input wire-frame model as the previous brightness,

wherein said storage portion stores said offset as table information based on a relation between said previous brightness stored in said frame buffer and the brightness of the next input wire-frame model.

9. A flicker inhibition method for inhibiting flicker caused by a difference in brightness when an input wire-frame model is displayed by a liquid crystal cell, comprising the steps of:

storing a relation between brightness in a stationary state in which a wire-frame model having a predetermined gray scale is displayed on a particular pixel and a plurality of frames and brightness in a moving state in which the wire-frame model having the predetermined gray scale changes frame to frame with respect to the particular pixel;

applying an offset based on said stored relation to the gray scale of said wire-frame model if said input wire-frame model is in a moving state; and

driving said liquid crystal cell based on said gray scale to which said offset is applied to display said wire-frame model.

10. The flicker inhibition method according to claim **9**, wherein said storing step said moving state brightness used for storing said relation is the brightness when said particular pixel changes back to the off state one frame after said particular pixel is driven from the off state to the on state during the passage of the wire-model frame over the particular pixel.

11. The flicker inhibition method according to claim **9**, wherein said storing step said brightness in the moving state which is used when said relation is stored is the quantity of light equal to a brightness change integrated with respect to time.

12. A liquid crystal driving method, comprising the steps of:

storing first brightness information for an input pixel in a frame buffer;

applying based on second brightness information for the next input pixel and said first brightness information stored in said frame buffer an offset for making the time integration quantity of a brightness change substantially equal to an ideal light quantity which is the brightness in a stationary state to said second brightness information;

outputting said second brightness information to which said offset is applied to a driving circuit for driving an liquid crystal cell; and

storing said second brightness information for the input pixel in a frame buffer.

13. The liquid crystal driving method according to claim **12**, wherein:

said step of storing said first brightness information in the frame buffer stores said first brightness information for each of said color signals and said input pixel comprises a plurality of color signals; and

said step of applying the offset applies said offset to each of said color signals.

14. The liquid crystal driving method according to claim **12**, wherein said offset applying step comprises the steps of reading a pre-stored offset based on a relation between said first and second brightness information and applying said read offset to said second brightness information.

* * * * *

EXHIBIT C

US006689629B2

(12) **United States Patent**
Tsujimura et al.

(10) **Patent No.: US 6,689,629 B2**
(45) **Date of Patent: Feb. 10, 2004**

(54) **ARRAY SUBSTRATE FOR DISPLAY, METHOD OF MANUFACTURING ARRAY SUBSTRATE FOR DISPLAY AND DISPLAY DEVICE USING THE ARRAY SUBSTRATE**

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(73) Assignee: **International Business Machines Corporation**, Armonk, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 54 days.

(21) Appl. No.: **10/068,500**

(22) Filed: **Feb. 5, 2002**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Feb. 6, 2001 (JP) 2001-029587

(51) **Int. Cl.**[7] **H01L 21/00**

(52) **U.S. Cl.** **438/25**; 438/149; 438/73; 257/72; 257/748

(58) **Field of Search** 438/25, 22, 30, 438/149, 73; 257/72, 748

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Primary Examiner—Caridad Everhart
(74) *Attorney, Agent, or Firm*—Tiffany L. Townsend

(57) **ABSTRACT**

Disclosed is to provide an array substrate for display, a method of manufacturing the array substrate for display and a display device using the array substrate for display.

The present invention is an array substrate for display, which includes: a thin film transistor array formed on an insulating substrate **1**; a plurality of wirings **23** and **24** arranged on the insulating substrate **1**; connection pads **25** and **27** arranged on unilateral ends of the wirings **23** and **24** and respectively connected therewith; and pixel electrodes **22**, wherein dummy conductive patterns **29** are arranged between the ends of the connection pads **25** and **27** and ends of the pixel electrodes **22**.

16 Claims, 11 Drawing Sheets

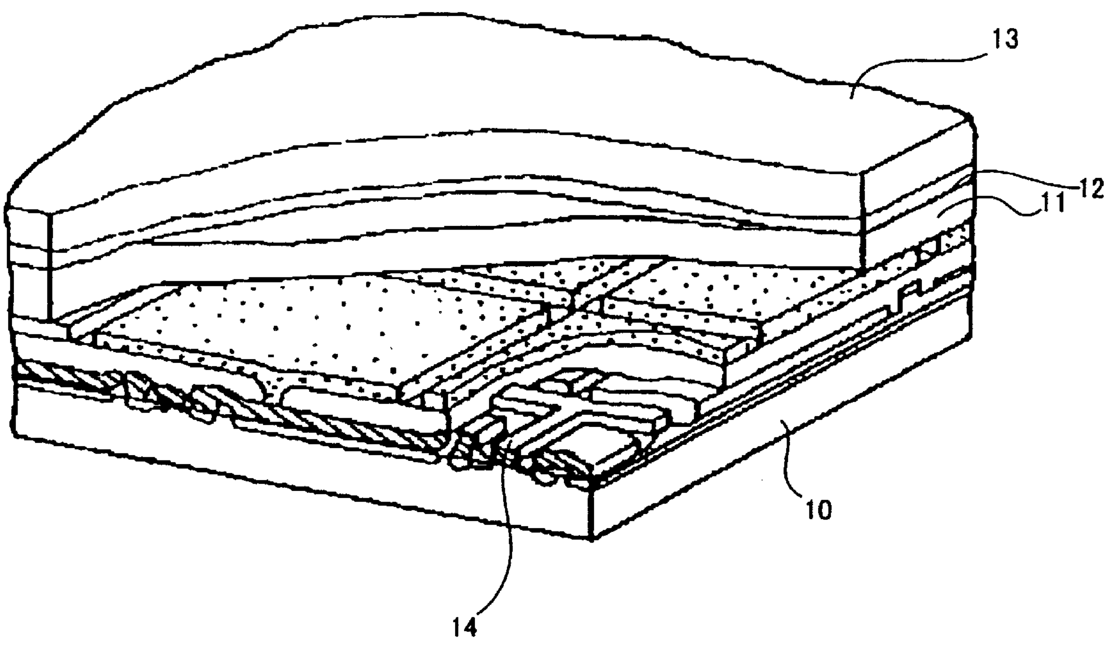


FIG. 1

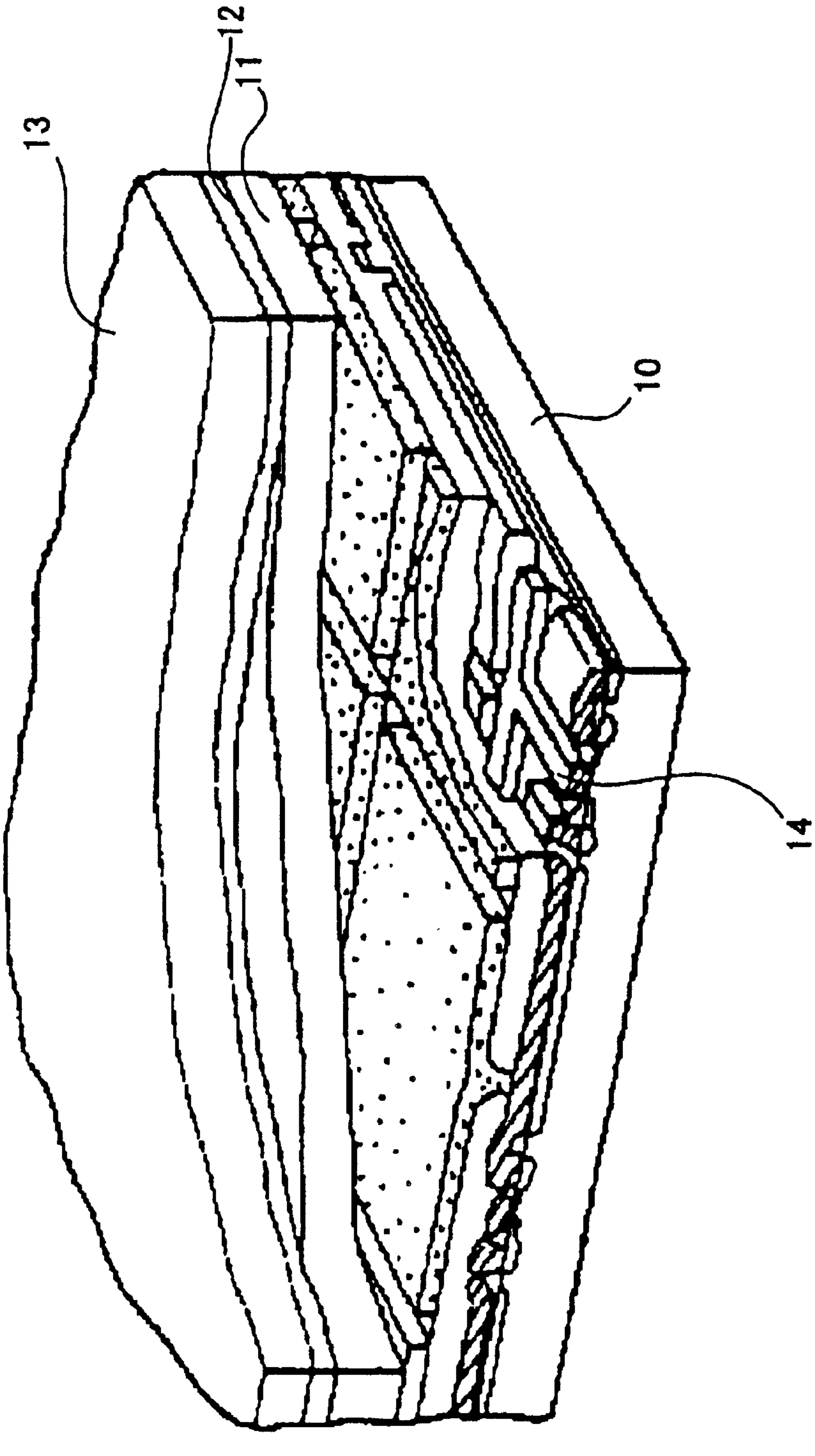


FIG. 2

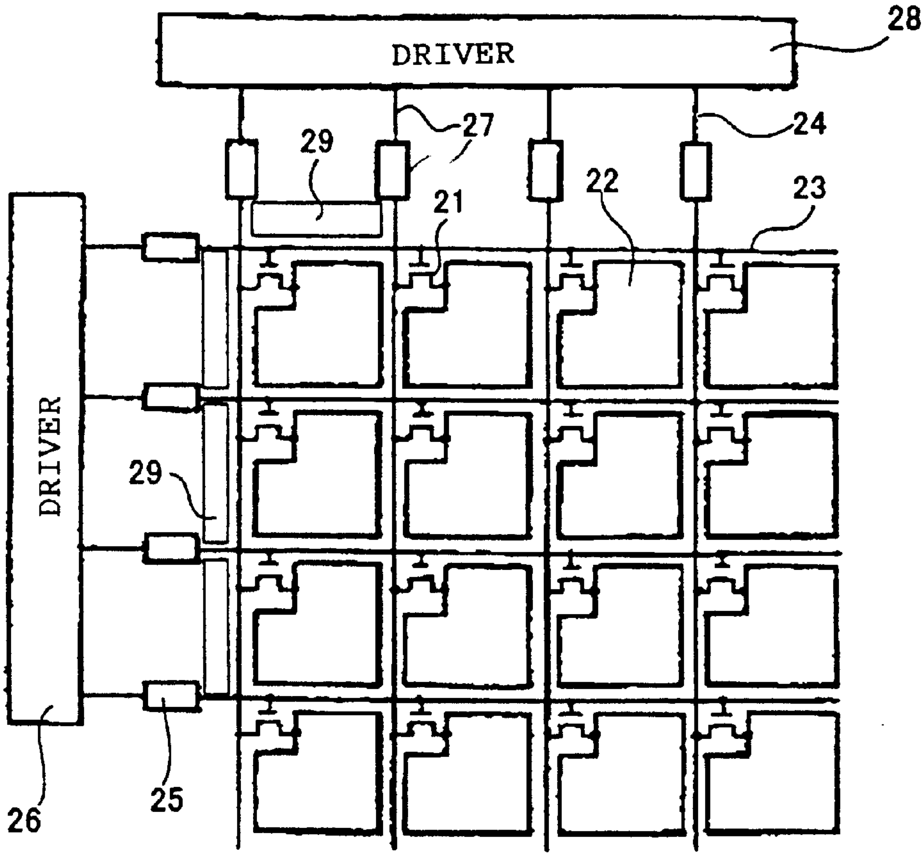


FIG. 3

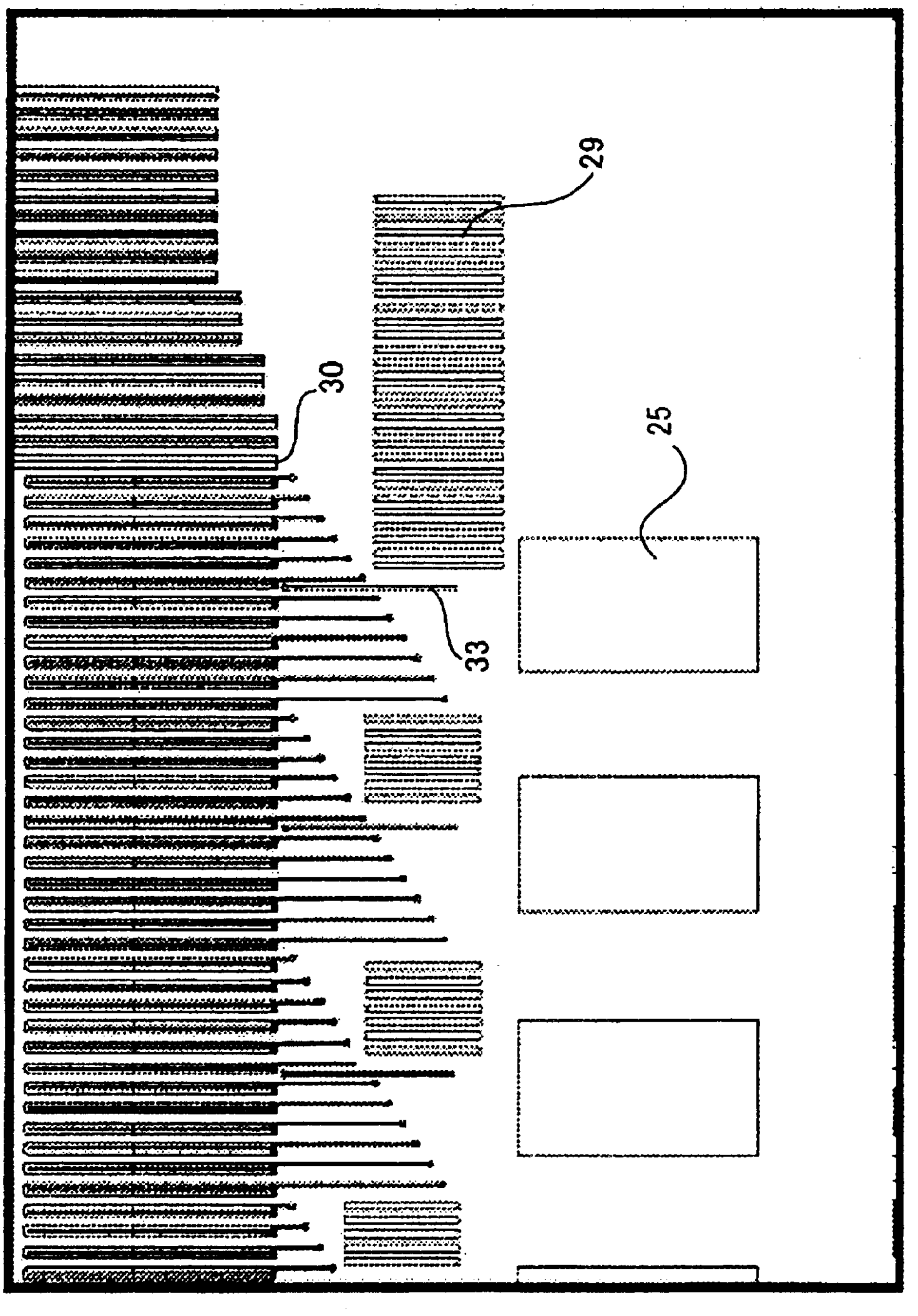


FIG. 4

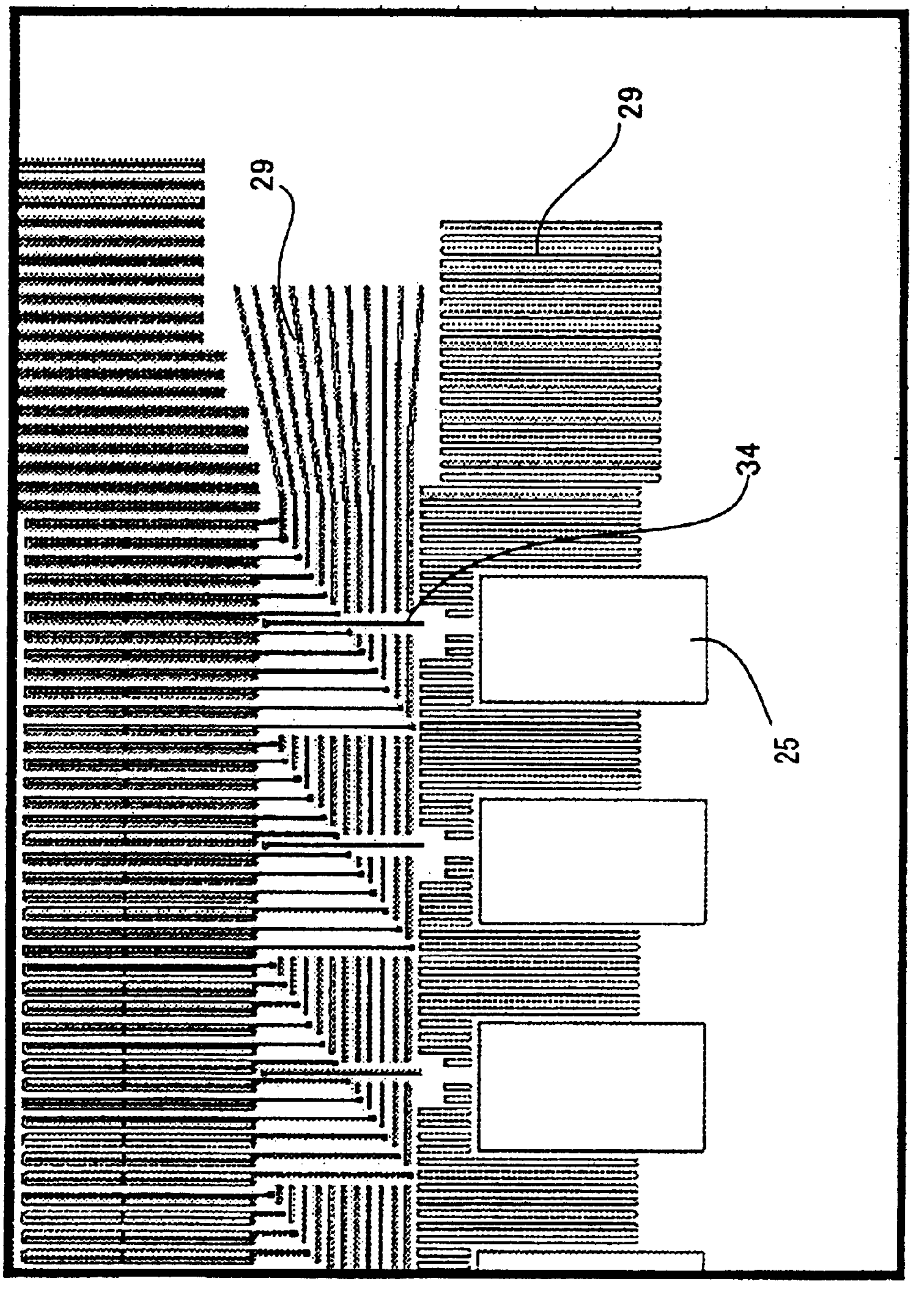
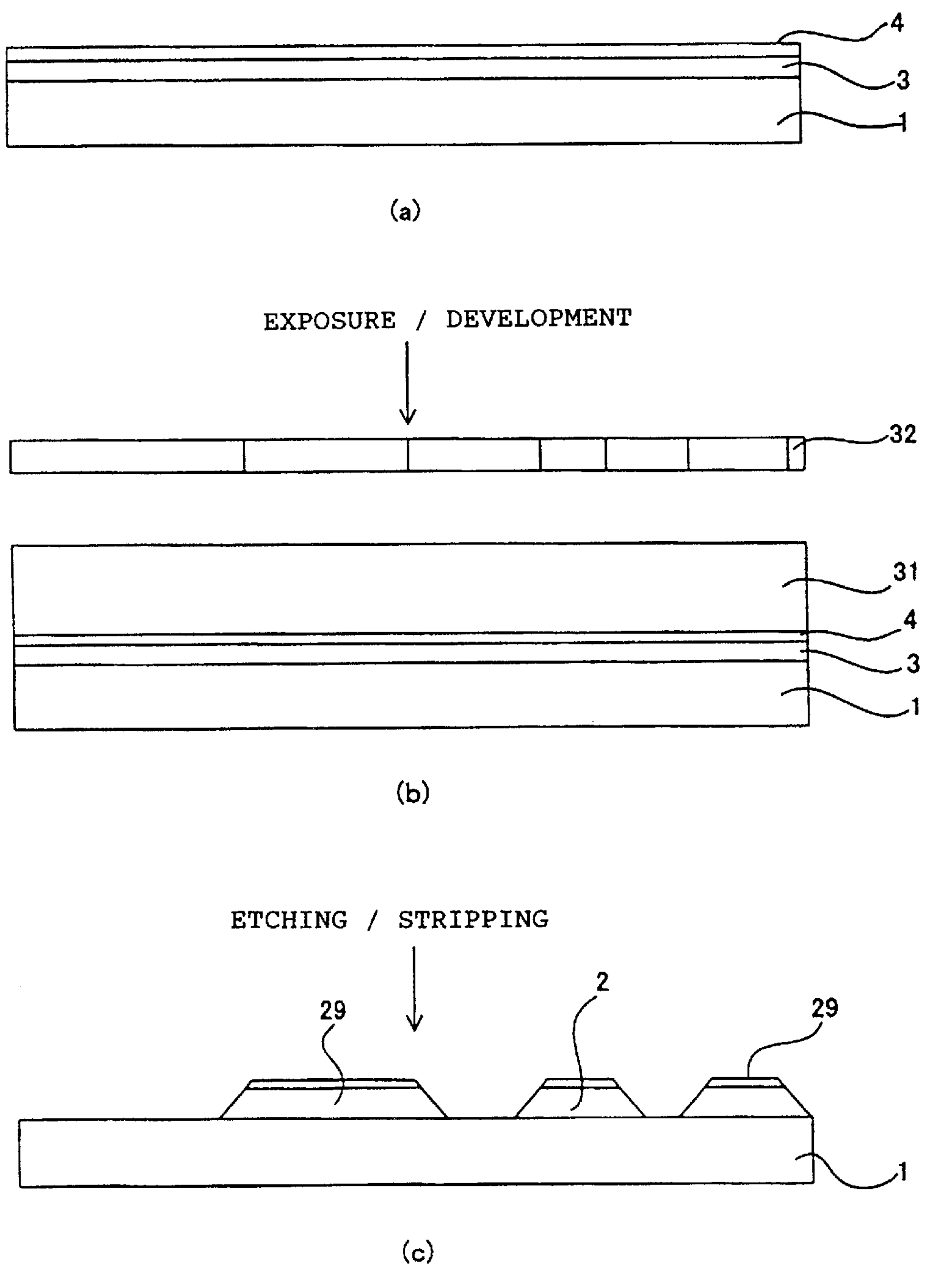


FIG. 5



4
3
1
(a)
EXPOSURE / DEVELOPMENT
32
31
4
3
1
(b)
ETCHING / STRIPPING
29
2
29
1
(c)

FIG. 6

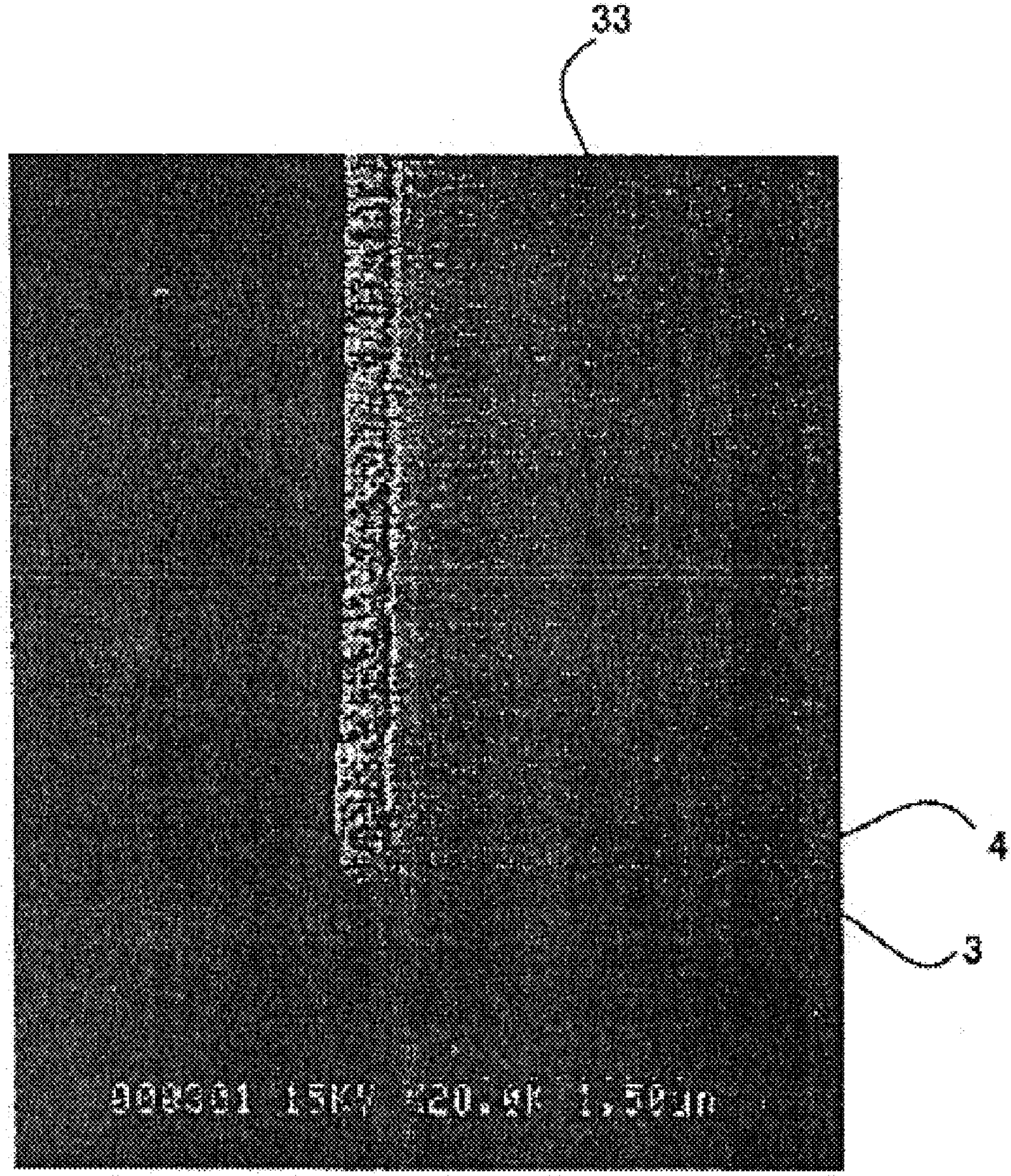


FIG. 7

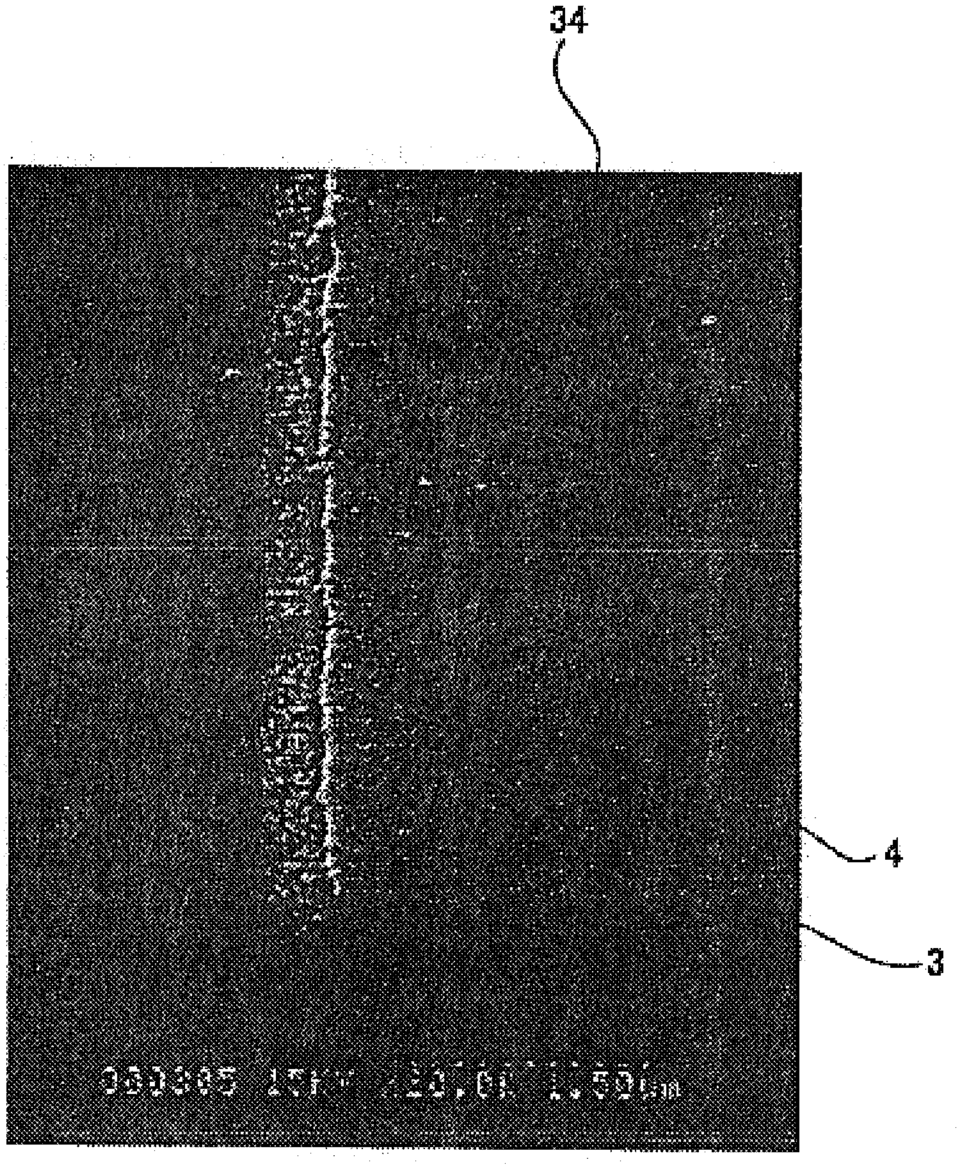


FIG. 8

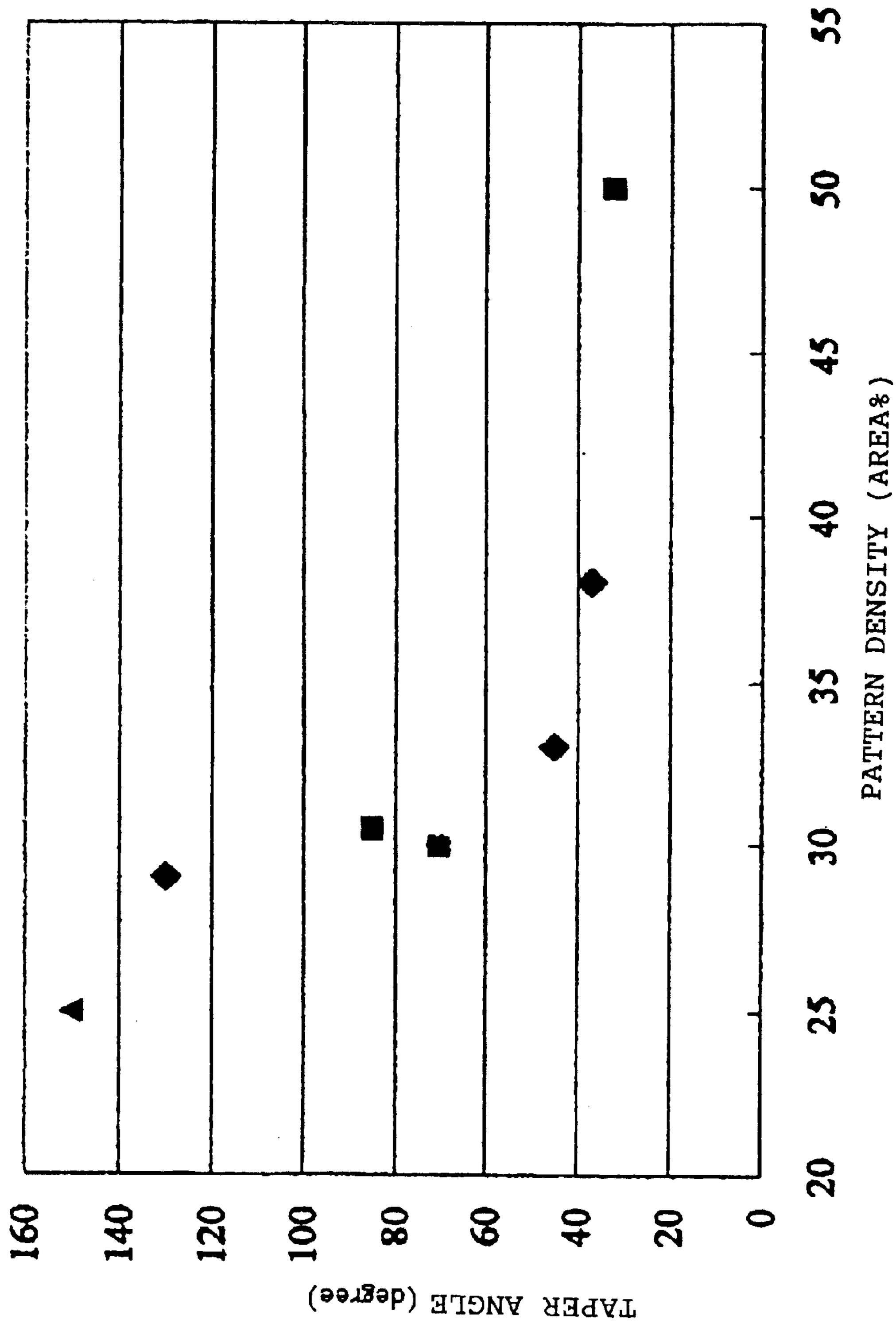

TAPER ANGLE (degree)
160
140
120
100
80
60
40
20
0
PATTERN DENSITY (AREA%)
20
25
30
35
40
45
50
55

FIG. 9

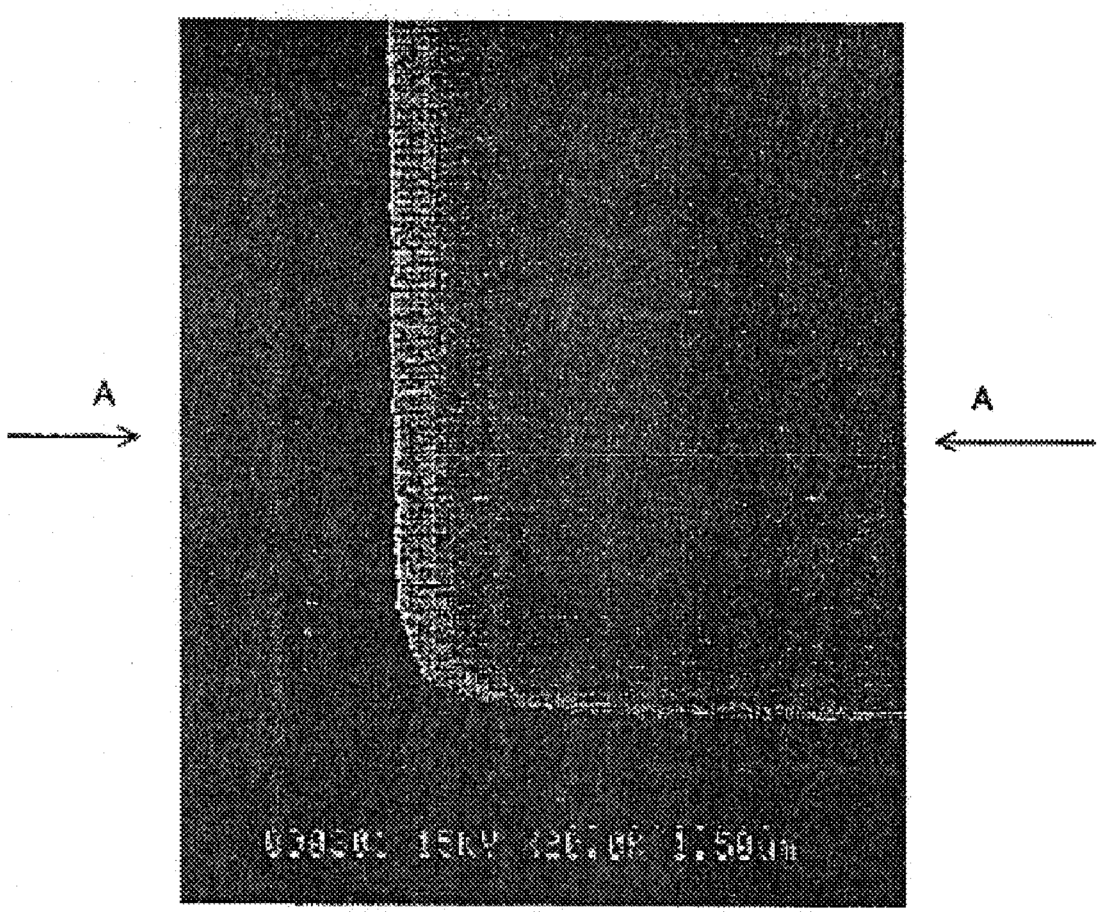


FIG. 10

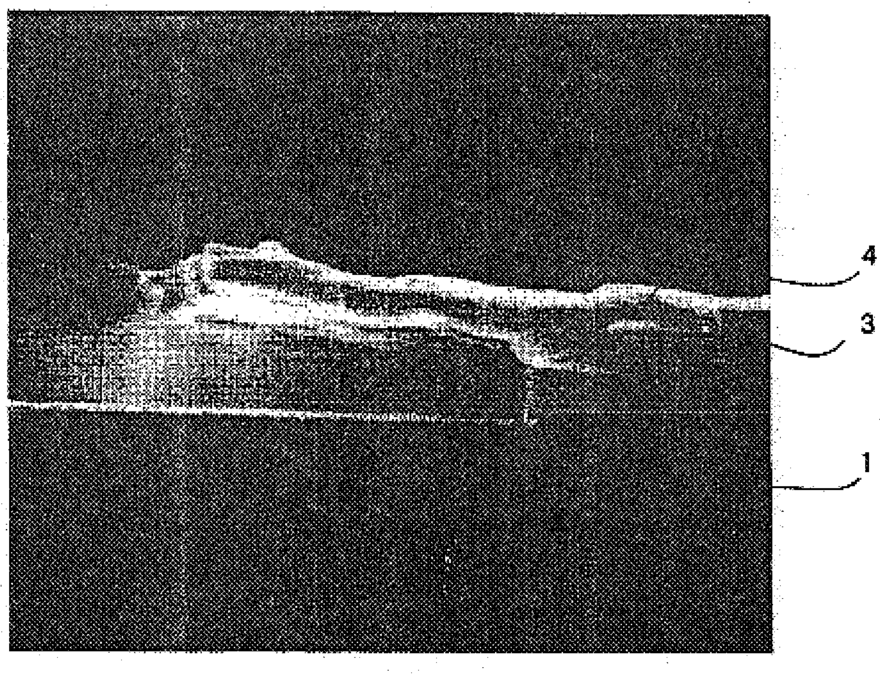


FIG. 11

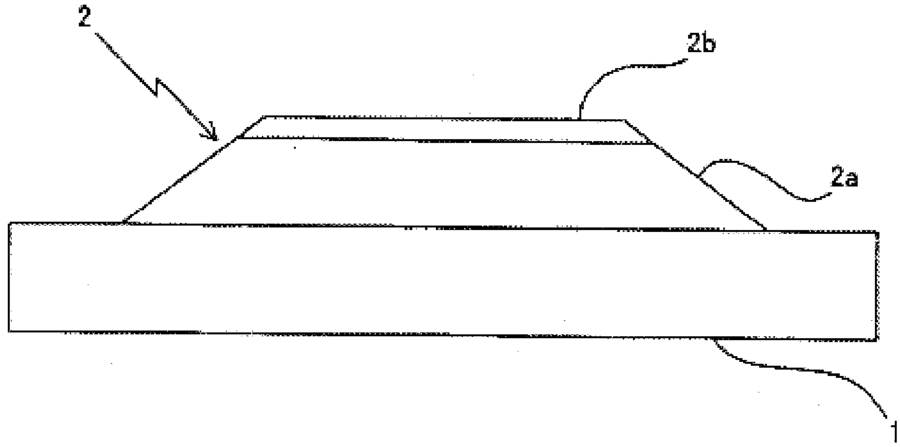
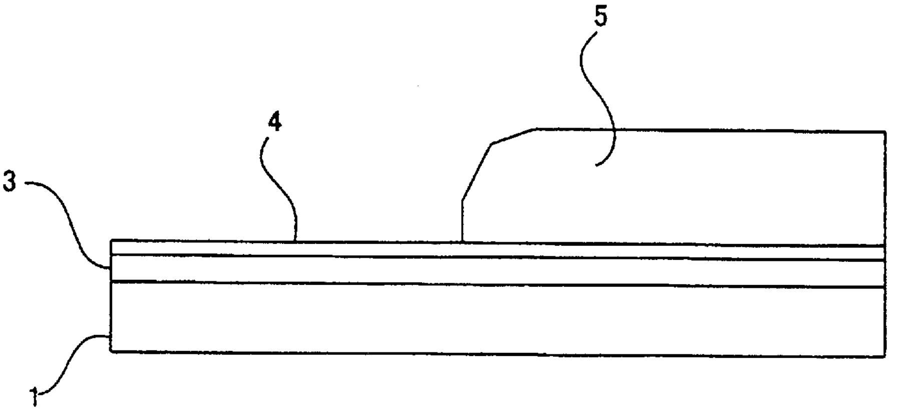
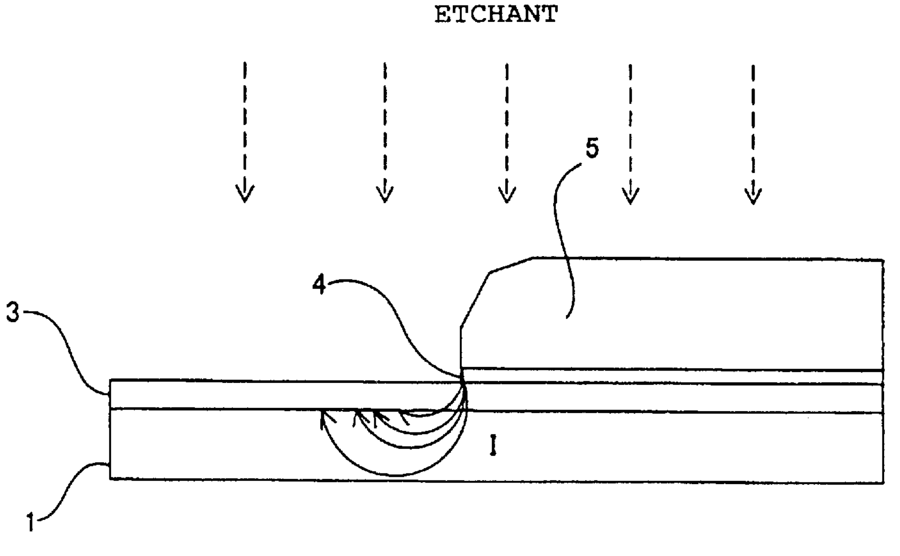


FIG. 12



(a)



(b)

ARRAY SUBSTRATE FOR DISPLAY, METHOD OF MANUFACTURING ARRAY SUBSTRATE FOR DISPLAY AND DISPLAY DEVICE USING THE ARRAY SUBSTRATE

BACKGROUND OF THE INVENTION

The present invention relates to an array substrate for display, a method of manufacturing the array substrate for display and a display device using the array substrate for display.

A display device using a thin film transistor (TFT) array has been frequently used owing to low power consumption and capability of downsizing the display device. The thin film transistor array is manufactured by forming thin film transistors, each being composed of electrodes such as a gate electrode, a source electrode and a drain electrode, wirings such as scan lines and signal lines connected with the above-mentioned electrodes, and pixel electrodes on an insulating substrate.

In recent years, a higher operating speed, a higher resolution and a larger size have been required for the display device described above in many cases. A high speed and a high density have been required for each constituent component of the array for display, which forms a display device. Particularly, in order to operate the thin film transistor array at a high speed, it is preferable to use low-resistance aluminum (Al) for the wirings such as the scan lines and the signal lines since delay in gate pulses can be reduced and a writing speed to the thin film transistor can be increased.

Incidentally, aluminum tends to be easily oxidized in spite of its low resistance. Therefore, in many cases, wiring using aluminum is constituted as a two-layer structure, in which aluminum is used as a lower conductive material, and a material harder to be oxidized than aluminum such as chromium, tantalum, titanium or molybdenum is used as an upper conductive material. FIG. **11** is a view schematically showing a state where wiring **2** is deposited on an insulating substrate **1**. A lower conductive material film **2***a* is deposited on an insulating substrate **1** made of such as glass, and an upper conductive material film **2***b* is deposited on the lower conductive material film **2***a*. Each of these films **2***a* and **2***b* is patterned by, for example, a proper etching process so as to have tapered ends.

In order to form a tapered shape shown in FIG. **11**, an etching rate for the upper conductive material is required to be increased. In order to form the tapered shape shown in FIG. **11**, various methods have been proposed up to now. For example, in the gazette of Japanese Patent Laid-Open No. Hei 10 (1998)-90706, a method has been proposed, in which dummy connection pads are provided on sides opposite to scan line connection pads and signal line connection pads, respectively. According to this method, over etching due to an etchant that will be relatively increased by lowering wiring density at ends of the substrate is prevented. Thus, undercut of a lower conductive material **3** is prevented, and an interlayer short circuit is prevented by imparting a proper tapered shape to the wiring **2**.

However, though this method enables evenness of etching at the ends of the thin film transistor array substrate to be improved, the method cannot effectively prevent the undercut of the signal lines in a region where the wiring density is apt to be lowered from ends of the pixel electrodes to the connection pads, for example, in a portion where drawing wiring is formed.

Moreover, in the gazette of Japanese Patent Laid-Open No. Hei 10 (1998)-240150, disclosed is a method of forming a tapered shape at an angle ranging from 20 degrees to 70 degrees on wiring constituted of two layers, in which a pad formed of aluminum and metal such as molybdenum formed on the aluminum is subjected to wet etching. According to this method, a specified tapered shape can be imparted to the wiring formed of a conductive film of a two-layer structure by the wet etching. However, the method never discloses a method of evenly etching a substrate region while maintaining a selection ratio thereof even in the substrate region where the wiring density is lowered.

FIGS. **12**A and **12**B are enlarged schematic views for explaining a patterning process using a conventionally used wet process in order to impart the above-described tapered shape to the wiring. As shown in FIG. **12**A, the lower conductive material **3** and an upper conductive material **4** are deposited on the insulating substrate **1** by a method such as physical vapor deposition. FIG. **12**A shows that a photoresist film **5** is coated on a film of the upper conductive material **4** and is patterned in a desired shape. The respective films are etched by an etchant such as a solution of phosphoric acid, nitric acid, acetic acid or mixtures thereof, and desired tapered shapes are formed thereon.

FIG. **12**B is a view for explaining an electrochemical process generated as each film is being etched when the wiring constituted of the upper conductive material **4** and the lower conductive material **3** is subjected to wet etching. In FIG. **12**B, an internal layer portion of the upper conductive material **4** coated with the photoresist film **5** is not dissolved. However, at the end of the photoresist film **5**, the upper conductive material **4** is dissolved by the etchant. When the wiring is formed by the wet etching, the upper conductive material **4** protected by the photoresist film **5** is further dissolved in a lateral direction from the end of the photoresist film **5** to turn into positive ions, and electrons emitted as a result are supplied to the lower conductive material **3**. Thus, the upper conductive material **4** serves as an anode. In this connection, the lower conductive material **3** comes to serve as a cathode. Accordingly, an electrochemical cell is formed. Here, when the etching rate for the upper conductive material **4** is increased to form a required tapered shape, the density of the electrons generated by dissolving the upper conductive material **4** and flowing to the lower conductive material **3** is increased accompanied with an increase of a dissolution rate of the upper conductive material **4**. FIG. **12**B schematically shows currents I flowing from the upper conductive material **4** to the lower conductive material **3**.

As the etching rate is increased, the density of the current flowing to an area of the upper conductive material **4**, which is exposed to the etchant, exceeds a current density causing passivity of the upper conductive material **4**. In such a case, the upper conductive material **4** is passivated not to be dissolved by the etchant, and only the lower conductive material **3** is dissolved accompanied with the progress of the etching, resulting in the occurrence of the undercut. When such undercut occurs, the wiring, for example, the gate wiring cannot be sufficiently coated with an insulating film in some cases, thus causing inconvenience such as an interlayer short circuit, resulting in lowering a yield of the display device.

SUMMARY OF THE INVENTION

The present invention was made with the foregoing problems in mind. An object of the present invention is to

provide an array substrate for display, a method of manufacturing an array substrate for display and a display device using the array substrate for display, which are capable of being etched at a sufficiently high etching rate and a sufficient selection ratio, eliminating undercut, and providing a large-sized and high-resolution display device.

The foregoing object of the present invention is achieved by providing the array substrate for display, the method of manufacturing an array substrate for display and the display device using the array substrate for display of the present invention.

Specifically, according to the present invention, provided is an array substrate for display, comprising: a thin film transistor array formed on an insulating substrate; a plurality of wirings arranged on the insulating substrate; connection pads arranged on unilateral ends of the wirings and respectively connected with the wirings; pixel electrodes, and dummy conductive patterns arranged between the ends of the connection pads and ends of the pixel electrodes. The dummy conductive patterns can occupy 30 area % or more. In the present invention, the dummy conductive patterns can be formed as any of land patterns and line-and-space patterns. In the present invention, the wirings are constituted of a lower conductive material and an upper conductive material, and the lower conductive material can be any one of aluminum and an aluminum alloy. In the present invention, the upper conductive material has a passivating potential. The upper conductive material can be any one of molybdenum and a molybdenum alloy.

According to the present invention, provided is a method of manufacturing an array substrate for display, the method comprising the steps of: forming a thin film transistor array including: a plurality of wirings arranged on an insulating substrate; and connection pads arranged on unilateral ends of the wirings and respectively connected with the wirings; forming pixel electrodes; and forming dummy conductive patterns between ends of the connection pads and ends of the pixel electrodes. In the present invention, it is preferable that the dummy conductive patterns be formed so as to occupy 30 area % or more. In the present invention, the dummy conductive patterns can be formed as any of land patterns and line-and-space patterns. In the present invention, the wirings are constituted of a lower conductive material and an upper conductive material, the lower conductive material can be any one of aluminum and an aluminum alloy, and the upper conductive material can be any one of molybdenum and a molybdenum alloy. In the present invention, the wirings are formed by wet etching.

Moreover, in the present invention, provided is a display device, comprising the array substrate for display mentioned above.

In the present invention, the display device used as a liquid crystal display device or an electroluminescence display device can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings.

FIG. **1** is a view showing an embodiment of a liquid crystal display device using an array substrate for display of the present invention.

FIG. **2** is a top plan view of the array substrate for display of the present invention.

FIG. **3** is an enlarged view showing a dummy conductive pattern in the present invention.

FIG. **4** is an enlarged view showing another dummy conductive pattern in the present invention.

FIGS. **5**A to **5**C are views illustrating a method of manufacturing the array substrate for display of the present invention.

FIG. **6** is an electron microscope photograph showing a pattern shape of wiring in the case of using the dummy conductive pattern shown in FIG. **3**.

FIG. **7** is an electron microscope photograph showing a pattern shape of wiring in the case of using the dummy conductive pattern shown in FIG. **4**.

FIG. **8** is a graph showing a relation between a taper angle of the wiring and a pattern density of the wiring.

FIG. **9** is an electron microscope photograph showing a wiring shape in the case of performing etching without using the dummy conductive pattern.

FIG. **10** is an electron microscope photograph showing a sectional shape of the wiring shape shown in FIG. **9**.

FIG. **11** is a schematic view showing a tapered shape of the wiring.

FIGS. **12**A and **12**B are views showing currents formed by a cell formed during an etching process.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinbelow, description will be made in detail for the present invention with reference to embodiments shown in the accompanying drawings. However, the present invention is not limited to the embodiments shown in the drawings.

FIG. **1** is a partially cutaway perspective view showing an embodiment of a display device using an array substrate for display of the present invention. As shown in FIG. **1**, the display device of the present invention is constituted by sequentially laminating a liquid crystal layer **11**, a transparent electrode **12** and a glass substrate **13** on an array substrate **10** for display, which is formed on an insulating substrate. Wiring **14** formed on the insulating substrate **10** is extended to an end (not shown) of the array substrate for display, and is connected with a driving system (not shown) through a connection pad (not shown).

FIG. **2** is a top plan view of the display device using the array substrate **10** for display of the present invention, which is shown in FIG. **1**. In the array substrate **10** for display of the present invention, a plurality of thin film transistors **21** constitute an array. A pixel electrode **22** is connected with each thin film transistor **21** that controls a potential of the pixel electrode. In the array substrate **10** for display shown in FIG. **2**, what is further shown is that a scan line **23** and a signal line **24** are connected with each thin film transistor **21**.

The respective scan lines **23** are connected with a driver **26** through scan line connection pads **25**, and the respective signal lines **24** are connected with a driver **28** through signal line connection pads **27**. These scan lines **23** and the signal lines **24** are formed so as to have the same constitution. As shown in FIG. **11**, each of these lines is constituted of the lower conductive material **3** and the upper conductive material **4**.

In the present invention, aluminum can be used for the lower conductive material **3** usable as wiring from a viewpoint of lowering resistance thereof. Moreover, it is preferable to use molybdenum (Mo) for the upper conductive material **4** usable in the present invention from a viewpoint of protecting the aluminum. However in the present invention, besides the aluminum, an aluminum alloy can be used for the lower conductive material **3**. Moreover, for the

upper conductive material **4**, alloys of chromium, tantalum, titanium and molybdenum can be used. Film thickness of the lower conductive material **3** is not particularly limited, but film thickness of the upper conductive material **4** is preferably thick since a current tends to be concentrated thereto as the film thickness becomes thinner. However, a problem regarding stress occurs as the thickness becomes thicker. Therefore, in the present invention, it is preferable to set the film thickness of the upper conductive material **4** in a range of 30 to 100 nm.

The present invention makes it possible to prevent undercut of the lower conductive material **3**, which occurs due to passivity of the upper conductive material **4**. In the present invention, the term "passivity" is referred to as a phenomenon that metal such as molybdenum or a metal alloy such as a molybdenum alloy becomes insoluble in an acid or alkaline etchant. For example, the term "passivity" is referred to as a phenomenon that metal serving as an anode becomes insoluble in such etchant. In the present invention, specifically as for such passivated metal or a metal alloy, metal or a metal alloy with a passivating potential, that is, a Flade potential can be mentioned. Note that, in the present invention, the Flade potential is referred to as a potential which causes a current density for passivating metal, which is described in the Encyclopedia Chimica (miniature edition 32nd printing, issued by Kyoritsu Shuppan Co., Ltd., edited by editorial committee of the Encyclopedia Chimica), vol. 7, p. 911.

Furthermore, in the embodiment shown in FIG. **2**, dummy conductive patterns **29** are disposed between the pixel electrodes **22** and each scan line connection pad **25** and between the pixel electrodes **22** and each signal line connection pad **27**. Thus, the wiring density is increased. Therefore, it is made possible to form good wiring over the entire surface of the array substrate for display without causing defects such as undercut and a mouse hole of the lower conductive material **3** during etching for the scan lines **23** and the signal lines **24**. Each of these dummy conductive patterns **29** can be formed as a two-layers structure with the same materials as those of the scan lines **23** and the signal lines **24** at the same time when the patterning is performed therefor.

FIG. **3** is an enlarged view showing a portion where the dummy conductive pattern **29** is formed in the embodiment of the array substrate **10** for display of the present invention shown in FIG. **2**. FIG. **3** shows the dummy conductive pattern **29** formed as a line-and-space pattern between the connection pad **25** and an end **30** of the pixel electrode. In the present invention, the dummy conductive pattern **29** can be formed as the line-and-space pattern shown in FIG. **3**. Alternatively, the dummy conductive pattern **29** can be formed as a land pattern completely coating a region where the dummy conductive pattern **29** is formed.

In any case of the patterns, in the present invention, it is preferable that the wiring density of the dummy conductive patterns **29** themselves be 30% or more on an area of a specified surface from a viewpoint of forming a properly tapered shape on the lower conductive material **3** without forming the undercut thereto while dissolving the upper conductive material **4** at a required rate.

Moreover, when the dummy conductive patterns **29** are arranged in the present invention, it is more preferable that the dummy conductive patterns **29** be formed between the end **30** of the pixel electrode **22** and each connection pads **25** and **27** so that the wiring density including the dummy conductive patterns **29** can be 30% or more on the area of a specified surface. In the present invention, the term "wiring density" refers to an area ratio of an area of portions where the signal lines, the scan lines, the drawing lines, and the dummy conductive patterns are formed on an area of a specified region where the dummy conductive patterns are formed.

FIG. **4** is a view showing another embodiment of the dummy conductive pattern **29** of the present invention. In the embodiment shown in FIG. **4**, the dummy conductive pattern **29** is disposed so that the wiring density thereof, which is specified at 30% or more, is further increased, thus reducing concentration of electric current to exposed portions of the upper conductive material to the etchant during the etching. As shown in FIG. **4**, the dummy conductive pattern **29** may have any shapes and any patterns. Moreover, any combination of a plural type of the dummy conductive patterns **29** can be used.

FIGS. **5**A, **5**B and **5**C are views showing an embodiment of a method of manufacturing the array substrate **10** for display of the present invention. With reference to FIG. **5**, description will be made for the method of manufacturing the array substrate **10** for display of the present invention, exemplifying a case where the thin film transistor **21** of a reverse stagger type is formed. First, as shown in FIG. **5**A, the lower conductive material **3** using aluminum and the upper conductive material **4** using molybdenum are deposited on the transparent or untransparent insulating substrate **1**, thus forming a film.

Next, as shown in FIG. **5**B, photoresist **31** is coated on the film. The photoresist is exposed and developed by use of a photo mask **32** provided with patterns for forming the dummy conductive patterns **29** in portions where the wiring density is lowered between the pixel electrodes and the connection pads, which are not particularly shown.

Subsequently, etching is performed by use of an etchant such as a solution of phosphoric acid, nitric acid, acetic acid and mixtures thereof, thus forming the wiring **2** and the dummy conductive patterns **29**. The dummy conductive patterns **29** are arranged in the portions where the wiring density is low. Thus, it is made possible to form wirings having good tapered shape as shown in FIG. **5**C even in regions where the conductive material such as molybdenum tends to be passivated. A taper angle can be set in a range of 20 degrees to 70 degrees by adjusting a composition of the etchant and etching conditions. It is more preferable to set the taper angle in a range of about 20 degrees to about 60 degrees.

Thereafter, in the present invention, gate insulating films, the gate electrodes, the source electrodes, the drain electrodes, the pixel electrodes and the like are formed, thus the array substrate **10** for display of the present invention is manufactured. In the present invention, the dummy conductive patterns **29** may be removed if necessary. Alternatively, the dummy conductive patterns **29** may be left as they are without being eliminated.

FIG. **6** is an electron microscope photograph showing a shape of the wiring **33** shown in FIG. **3**, which was obtained when the dummy conductive pattern **29** shown in FIG. **3** was provided and the etching was performed. In this case, molybdenum was used for the upper conductive material **4**, and aluminum was used for the lower conductive material **3**. The film thickness of molybdenum is about 50 nm, and wet etching is performed by use of an etchant of a mixed solution of phosphoric acid, nitric acid and acetic acid. As shown in FIG. **6**, a good tapered shape is formed even in a wiring portion where the undercut is formerly apt to occur by forming the dummy conductive pattern **29**.

FIG. **7** is a photograph showing a shape of the wiring **34** shown in FIG. **4**, which was obtained when the dummy conductive pattern **29** shown in FIG. **4** was formed and the etching was performed under the same conditions as those in FIG. **6**. As shown in FIG. **7**, even when the density of the dummy conductive pattern **29** is increased, a good tapered shape is obtained.

FIG. **8** is a graph plotting values of the taper angle of the formed wiring relative to values of the pattern density (area %) of the wiring including the portions of the dummy conductive patterns **29** on the substrate when the dummy conductive patterns **29** are arranged. As shown in FIG. **8**, the taper angle of the wiring obtained by the etching is reduced as the pattern density of the wiring is increased, and a more gentle taper is formed. Therefore, it is understood that the upper conductive material **4** can impart a sufficient selective ratio to the etching of the lower conductive material **3** by arranging the dummy conductive patterns **29**.

FIG. **9** is an electron microscope photograph showing, for comparison, a shape of wiring obtained when etching is performed by use of the array substrate **10** for display, which has the same pattern as those shown in FIGS. **3** and **4**, but without forming the dummy conductive patterns **29** at all. As shown in FIG. **9**, large undercut occurs in the wiring since the molybdenum used for the upper conductive material **4** is passivated, and only the etching for the aluminum as the lower conductive material **3** progresses.

FIG. **10** is an electron microscope photograph showing a cross section taken along a cutting plane line A—A of the wiring shown in FIG. **9**. As shown in FIG. **10**, the etching for the aluminum used for the lower conductive material **3** progresses more than that for the molybdenum used for the upper conductive material **4**, resulting in the occurrence of the great undercut.

The present invention can be applied not only to the thin film transistor of a reverse stagger type as described above but also to a thin film transistor of a top gate type including wiring formed of aluminum and any metal other than the aluminum, of which passivating current density is known.

Moreover, although the array device for display of the present invention can be applied to a liquid crystal display device using a transparent insulating substrate made of such as glass, the array device for display of the present invention can be also used as an organic or inorganic electroluminescence device, wherein an untransparent insulating substrate is used and an array for display is formed on the insulating substrate.

As described above, according to the present invention, it is made possible to provide an array substrate for display, a method of manufacturing an array substrate for display and a display device using the array substrate for display, which are capable of being etched at a sufficiently high etching rate and a sufficient selection ratio, and eliminating the under cut and the lowering of a yield in manufacturing due to the inconvenience such as an interlayer short circuit. Moreover, according to the present invention, it is made possible to provide an array substrate for display, a method of manufacturing an array substrate for display and a display device using the array substrate for display, which are capable of providing a large-sized and high-resolution display device.

Although the preferred embodiments of the present invention have been described in detail, it should be understood that various changes, substitutions and alternations can be made therein without departing from spirit and scope of the inventions as defined by the appended claims.

What is claimed is:

1. An array substrate for display, comprising:

a layer of an insulating substrate, having an area;

a thin film transistor array formed on the insulating substrate;

a plurality of wiring arranged on the insulating substrate, each wiring having a first end, the wiring in communication with at least one of the transistors in the thin film array;

connections pads, each connection pad contacting the first end of at most one of the plurality of wirings;

pixel electrodes, and

dummy conductive patterns, the dummy patterns comprising at least about 30% of the area of the insulating substrate, the dummy conductive patterns situated between the connection pads and the pixel electrodes such that the dummy patters are not in contact with any of the wiring.

2. The array substrate for display according to claim **1** wherein at least one of the wirings comprises at least an upper layer and a lower layer of conductive materials.

3. The array substrate for display according to claim **2** wherein the lower layer wiring material is selected from the group consisting of aluminum and aluminum alloys.

4. The array substrate for display according to claim **2** wherein the upper layer wiring material is selected from the group consisting of molybdenum, chromium, tantalum, titanium and alloys thereof.

5. The array substrate for display according to claim **3** wherein the upper layer wiring material is selected from the group consisting of molybdenum, chromium, tantalum, titanium and alloys thereof.

6. The array substrate for display according to claim **5** wherein the upper wiring material is selected from the group consisting of molybdenum and alloys thereof.

7. The array substrate for display according to claim **4** wherein the upper layer wiring material is selected such that the upper layer wiring material does not become insoluble in an acid or alkaline etchant.

8. The array substrate for display according to claim **5** wherein the upper layer wiring material is selected such that the upper layer wiring material does not become insoluble in an acid or alkaline etchant.

9. A meted for forming an array substrate for display, comprising:

forming a layer of an insulating substrate, having an area;

forming a thin film transistor array formed on the insulating substrate, each wiring having a first end, the wiring in communication with at least on of the transistors in the thin film array;

forming connections pads, each connection pad contacting the first end of at most one of the plurality of wirings;

forming pixel electrodes, and

forming dummy conductive patterns, the dummy conductive patterns comprising at least about 30% of the area of the insulating substrate, the dummy patterns situated between the connection pads and the pixel electrodes such that the dummy patters are not in contact with any of the wiring.

10. The method for forming an array substrate for display according to claim **9** wherein at least one of the wirings comprises at least an upper layer and a lower layer of conductive materials.

11. The method for forming an array substrate for display according to claim **10** wherein the lower layer wiring materials is selected from the group consisting of aluminum and aluminum alloys.

12. The method for forming an array substrate for display according to claim **10** wherein the upper layer wiring material is selected from the group consisting of molybdenum, chromium, tantalum, titanium and alloys thereof.

13. The method for forming an array substrate for display according to claim **11** wherein the upper layer wiring material is selected from the group consisting of molybdenum, chromium, tantalum, titanium and allays thereof.

14. The method for forming an array substrate for display according to claim **13** wherein the upper wiring material is selected from the group consisting of molybdenum and alloys thereof.

15. The method for forming an array substrate for display according to claim **12** wherein the upper layer wiring material is selected such that the upper layer wiring material does not become insoluble in an acid or alkaline etchant.

16. The method for forming an array substrate for display according to claim **13** wherein the upper layer wiring material is selected such that the upper layer wiring material does not become insoluble in an acid or alkaline etchant.

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